THE ROYAL SOCIETY OF TASMANIA

THE ADVANCEMENT OF KNOWLEDGE

Papers and Proceedings of The Royal Society of Tasmania

Volume 155(1)
June 2021

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THE ADVANCEMENT OF KNOWLEDGE

MUSEUMS VICTORIA
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Papers and Proceedings of The Royal Society of Tasmania

Part 1 of Volume 155 has been prepared in recognition of the centenary of The Royal Society of Tasmania, Northern Branch.

1921 2021
THE ROYAL SOCIETY OF TASMANIA
NORTHERN BRANCH

Co-edited by Dr Sally Bryant and Ms Chel Bardell
and published by the Society

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The Royal Society of Tasmania acknowledges, with deep respect, the traditional owners of this land, and the ongoing custodianship of the Aboriginal people of Tasmania. The Society pays respect to Elders past, present and emerging.

We acknowledge that Tasmanian Aboriginal Peoples have survived severe and unjust impacts resulting from invasion and dispossession of their Country.

As an institution dedicated to the advancement of knowledge, the Royal Society of Tasmania recognises Aboriginal cultural knowledge and practices and seeks to respect and honour these traditions and the deep understanding they represent.

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Cover photograph: The legendary bushwalker and wilderness photographer Fred Smithies, overlooking the Cradle Mountain landscape from the top of The Spire, during the 'Skyline Climb' of 1936. Fred was awarded an OBE in 1946 and served as Royal Society of Tasmania Northern Branch President from 1939–1947. (Photograph courtesy of Margaret Carrington)

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 155(1)

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THE ROYAL SOCIETY OF TASMANIA

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FOREWORD

One hundred years of continuous operation is a significant achievement for any organisation, and especially notable for volunteers striving to advance the cause of knowledge across a variety of platforms. The lectures presented by the Northern Branch of the Royal Society of Tasmania and articles contributed to the annual journal *Papers and Proceedings* over the years form an important body of work adding to knowledge of natural, historical and cultural aspects of Tasmania. In this special issue, Dr Eric Ratcliff OAM, as incoming Northern Branch President and a member for over 50 years, offers his reflections accompanied by a complete list of Branch Presidents since 1921. Following this, a paper by Lynette Ross provides fascinating insights into the early days of the Northern Branch and the pivotal figures in its formation.

Following the Apology by the Society to Tasmanian Aboriginal people in February this year, we are committed to involving Aboriginal people more in the work of the Society. Dr Patsy Cameron AO, noted researcher and Aboriginal elder, has contributed a paper 'Tyereelore and Straitsmen: The true story of Tasmanian Aboriginal survival' that reveals and explores a nuanced interpretation of Tasmanian Aboriginal histories.

Having grown up in northern Tasmania and been thrilled by childhood visits to the planetarium at the Queen Victoria Museum and Art Galley (QVMAG), I am delighted that this special volume contains an account by Launceston-based astronomer Dr Martin George of how a small island state became a centre for astronomical research and education recognised worldwide. Some Tasmanian readers of this volume will remember being given 'goitre tablets' as we called them in primary school, containing iodine to combat the deficiency identified in Tasmania in the 1930s, and will read with special interest the article by Dr Paul Richards AM on the Tasmanian thyrotoxicosis epidemic of the 1960s.

The study of natural history has been an important focus of the Royal Society of Tasmania since its inception, and this volume contains an account by Martha McQueen of the many contributions made by the Central North Field Naturalists to improving nature conservation and education in Tasmania. The Northern Branch supported the acquisition by QVMAG of the nationally significant Lambkin-Knight butterfly collection, and David Maynard explains the importance of this collection to future research. Naturalists will also be interested to learn more about the endemic Tasmanian Digger Wasp in the article by David Maynard and Simon Fearn. On a subject close to the hearts of Tasmanians, Rachelle Hawkins explains how the aquarium industry is making an important contribution to improving the survival of two of the world's most unique marine fish species.

Studying the geological characteristics of Tasmania has been a key focus of the Society; in this volume, Dr Eric Ratcliff OAM continues this tradition by explaining the European uses of dolerite in Tasmania from early colonial times to the present day, and Dr Keith Corbett describes the geological history of the Tamar Valley and Launceston area during the making of Tasmania over 70 million years ago. Finally, Peter King outlines research led by the Australian Maritime College in Launceston to deploy autonomous underwater vehicles delving beneath Antarctic ice shelves to gather vital information about how glaciers change and melt.

On behalf of the membership of the Royal Society of Tasmania, I offer warmest congratulations to the Northern Branch on achieving the important milestone represented by this centenary. Having witnessed firsthand the dedication of the tireless band of volunteers and the thriving program they arrange, I am sure the Northern Branch is well on track for a further 100 years of lively and thought-provoking activities to advance knowledge. Sincere thanks go to everyone involved in the creation of this important special volume of the *Papers and Proceedings* including all the authors, Chel Bardell and the centenary committee, members of the publications committee and the Hon. Editor, Dr Sally Bryant, for their sterling work.

M. Koolhof

Mrs Mary Koolhof
President, The Royal Society of Tasmania

THE ROYAL SOCIETY OF TASMANIA

Northern Branch Presidents 1921 to 2021

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1925	Mr R.O. Miller
1926	Mr Herbert H. Scott
1927	Mr R.O. Miller
1928	Mr William R. Rolph
1929–1932	Mr Tasman Shields
1933–1934	Mr William R. Rolph
1935–1937	Mr Archibald L. Meston
1938	Mr Frank Heyward
1939–1947	Mr Fred Smithies OBE
1948–1949	Mr J.E. Heritage CMG
1950–1951	Dr Clifford Craig CMG
1952–1953	Mr Karl R. von Stieglitz OBE
1954–1955	Mr R.S. Smith
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1958–1959	Mr G. Hawley Stancombe
1960–1961	Dr Clifford Craig CMG
1962–1963	Mrs I.J. Mead
1964–1965	Mr Thomas E. Burns
1966–1967	Dr John C. H. Morris
1968	Mr J.N. Gee
1969	Dr John C.H. Morris
1970–1971	Mr J.N. Gee
1972–1973	Mr D. Walker
1974–1975	Dr Eric V.R. Ratcliff
1976–1977	Mr Peter G. Webb
1978–1979	Mr Harold Stan Payne
1980–1981	Mr D. Walker
1982	Mr Ron E. Ward
1983	Mr Bruce A. Pike
1984	Mr David G. Hannan
1985	Mrs Gillian M. Morris
1986	Mr Peter G. Webb
1987	Mrs Mary P. Cameron
1988	Mr Peter G. Webb
1989	Mr Allan T. Orr
1990	Dr Eric V.R. Ratcliff
1991	Mr Allan T. Orr
1992–1993	Mrs Mary P. Cameron AM
1994–1995	Mr Elvin Fist
1996–1997	Prof. Campbell McKnight

CHAIR

1998–1999	Mrs Christine Beswick
2000	Dr Lachlan Hardy Wilson AM
2001–2005	Position not filled
2006	Mr Elvin Fist (Acting Chair)
2007	Dr John C.H. Morris AO MBE

PRESIDENT

2008–2010	Mrs Mollie Campbell-Smith AM MBE
2011	Dr Eric V.R. Ratcliff OAM
2012–2013	Dr John Paull
2014	Dr Eric V.R. Ratcliff OAM
2015–2016	Dr Frank Madill AM
2017–2018	Mr David Morris
2019–2020	Dr Frank Madill AM
2021–	Dr Eric V.R. Ratcliff OAM

REFLECTIONS

For any voluntary organisation to maintain continuous activity in the pursuit of its stated aims for a century is cause for celebration in this era of constant change and new ways of communicating knowledge. While contemplating this, I realised that I have been a member of the Northern Branch for over half of its century, which provides some justification for my brief reflection on its achievements.

Past and present members of the Northern Branch, many of them serving on its committee, have been outstanding in the advancement of knowledge; and should a bibliography ever be produced it would record the substantial works and editions by Mary Cameron, Clifford Craig, Campbell McKnight, Frank Madill, Gillian Morris, John Paull, Brian Plomley, John Skemp, Hawley Stancombe, Karl von Stieglitz and Bertram Thomas, and the many papers and chapters published by Archibald Meston, Eric Scott, Peter Webb and John Morris, to name but a few. For example, the extended ichthyological series in the *Papers and Proceedings* by Eric Scott was particularly notable as it laid the foundation for the taxonomic classification of Tasmania's unique fish assemblages.

Other members have been influential in so many ways, such as the 'lantern lectures' of Fred Smithies that opened the eyes of Tasmanians to their scenic mountain ranges, and the pioneering aerial and botanical photography of Herbert King whose work featured in books on Tasmania's natural history and who, as a leading plant collector for *The Endemic Flora of Tasmania*, had a volume dedicated to him. For a time, one of Tasmania's foremost naturalists, the botanist and polymath Thomas Edgar Burns produced 'bulletins' embodying papers delivered at Branch meetings. The Branch has always promoted historical research and the natural sciences, and its learned members have been influential in the establishment of other durable organisations such as the Launceston Field Naturalists' Club, the Launceston Historical Society, and arguably the National Trust in Tasmania.

Members of the professions in particular, as well as others, have valued the breadth of vision beyond their accustomed fields that was, and still is, provided by our impressive regular speakers. The Branch has also involved itself in publication, notably of the first printing of Thomas Lempriere's *The Penal Settlements of Van Diemen's Land,* a historically significant 1839 manuscript that had previously lain dormant in a Sydney archive for decades. Other achievements have included the marking of significant sites in Tasmania's northern region, such as the observatory that fixed the latitude and longitude of Launceston, and the site of the York Town settlement at Port Dalrymple.

The Branch has maintained a long and valued association with the Queen Victoria Museum and Art Gallery in Launceston. Our meetings have been held at the Museum for the greater part of the century, our Branch library is housed there, and several Museum directors have been long-serving secretaries, notably Frank Ellis, Isabella Mead and Chris Tassel.

There was a time in the 1970s when the Branch was less active, but meetings and lectures continued under a small management committee including Patricia Ratcliff and Mollie Campbell-Smith, even when a full Branch Committee could not be assembled.

For a time, the Branch was also referred to as a 'Chapter', but chapters come to an end; branches continue to grow and put out leaves. May this signify our future as we continue into our second century.

Dr Eric Ratcliff OAM
2021 Northern Branch President

RESURRECTION: THE CREATION HISTORY OF THE ROYAL SOCIETY OF TASMANIA'S NORTHERN BRANCH

by Lynette Ross

(with four plates)

Ross, L. 2021 (2:vi): Resurrection: the creation history of the Royal Society of Tasmania's Northern Branch. *Papers and Proceedings of the Royal Society of Tasmania* 151(1): 1–7. ISSN: 0080-4703. 9 Adams Street, Mowbray 7248, Tasmania, Australia. Email: lynetteross4@bigpond.com

The date 27 June 1921 holds special significance for those in the north dedicated to the advancement of knowledge as it marks the inaugural lecture of the newly formed Northern Branch of the Royal Society of Tasmania. Yet, as will be demonstrated, this organisation was not undergoing creation but a reincarnation from its earlier counterpart. Knowledge of the first Branch and its activities is poorly known other than it originally flourished then faded into obscurity. Nevertheless, this group of dedicated enthusiasts persisted and today hold a special place in the story of the development of scientific bodies in the north of Tasmania including the nineteenth-century movement towards the establishment of public museums. As with all progressive endeavours, there were pivotal figures who stood out for the part they played in shaping events. Their names can be found in the following discussion.

Key Words: Royal Society of Tasmania, Northern Branch, Tasmanian history, museums.

THE TASMANIAN NATURAL HISTORY SOCIETY

The history of the Northern Branch of the Royal Society of Tasmania does not begin in 1921 when the current body was established but several decades earlier when an offshoot of the parent organisation was formed in 1853 by some of Launceston's most prominent citizens. Leading figures in its creation were local businessman William Henty and the naturalist Ronald Campbell Gunn, the latter of whom became Honorary Secretary (plate 1). The emergence of this Branch was part of a progression that reached back as far as 1838 when the Tasmanian Natural History Society (as it was called) was founded by the then Lieutenant-Governor of Van Diemen's Land, Sir John Franklin, with meetings being held at his official residence in Hobart Town.

Gunn had first visited Government House in mid-1837 and was much taken with the vice-regal couple. He later relayed that the new Lieutenant-Governor and his wife were '…sincerely desirous of forwarding the Cause of Natural History in this Colony…' by encouraging and supporting scientific research (Burns & Skemp 1961, p. 71). A society was being formed and Jane Franklin was occupied buying land for the establishment of a garden of indigenous plants. Gunn, himself an avid collector of botanical specimens, was soon absorbed into the circle of amateur scientists surrounding the Franklins and became a valued associate. The northern-based naturalist was also active locally, being instrumental in the setting up of the Launceston Horticultural Society in July 1838, an organisation today recognised as the longest continuously running horticultural society in Australia (*Launceston Advertiser* 20 Sept. 1838, p. 1; Mead 1960s, Sheridan 2013).

In 1841, the Tasmanian Natural History Society took an important step towards wider recognition when the first number of *The Tasmanian Journal of Natural Science,*

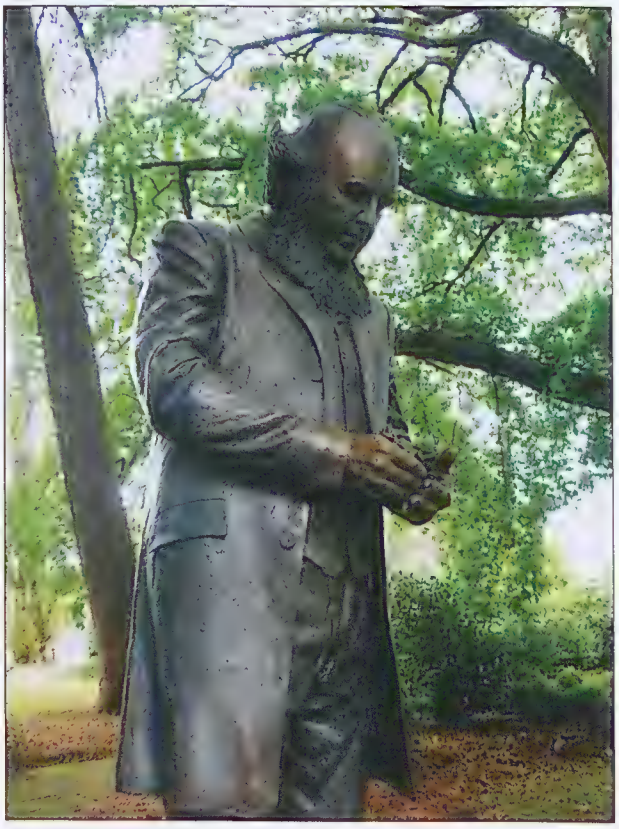


PLATE 1 — Statue of Ronald Campbell Gunn in the old Launceston Horticultural Society's grounds (now City Park). (Photograph: L. Ross)

Agriculture, Statistics, &c was published. An introduction by the Reverend John Lillie described the founding of the Society; how a philosophical group had been created by a few individuals to assist each other with the study of the natural history of the island. Once a fortnight they met in the library of Government House where papers were given, and these later became the material for the journal that resulted from the encouragement of their patron, Sir John Franklin. While the object of the journal was to present original material relating to the natural history and physics of the island with a concentration on botany, zoology, meteorology and geology, the content was not restricted to Van Diemen's Land and featured other Australian colonies, New Zealand, Antarctic regions and elsewhere as well as including a wide range of related subjects such as travel and exploration (Lillie 1842, Plomley 1969).

The Tasmanian Natural History Society was much grieved by the recall of their founder in 1843 and, as it turned out, the members were right to bewail Franklin's departure as they lost more than their friend and patron. His replacement, Sir Eardley-Wilmot, in an effort to defray the costs of maintaining the gardens at Hobart Town, founded the rival Botanical and Horticultural Society of Van Diemen's Land with the aim to "develop the physical character of the Island and illustrate its natural history and productions". The next year under royal patronage the name was changed to the Royal Society of Van Diemen's Land for Horticulture, Botany and the Advancement of Science and, after a few more adjustments, became the present-day Royal Society of Tasmania. Eardley-Wilmot's attempts to incorporate the Tasmanian Natural History Society were so tactless that the headquarters was relocated to Launceston where Gunn, its most active member, lived. He remained secretary and editor of the journal until 1848 when the Society finally amalgamated with the Royal Society of Tasmania under another Lieutenant-Governor, Sir William Denison (Piesse 1913, Burns & Skemp 1961, pp. 111–112). Yet, the departure of the Tasmanian Natural History Society from the scene proved not to be the end of Gunn's efforts to surround himself with like-minded enthusiasts.

CREATION OF THE NORTHERN BRANCH

The first sign of an attempt to establish a branch in the north was in September 1853 when an advertisement appeared in *The Launceston Examiner* stating the intention of forming an association, either independently or as an offshoot of the island's Royal Society. Those interested, including already existing members of the latter residing in the vicinity of the town, were requested to attend on the 26th of that month at Franklin Lodge, located within the main gates of what is now City Park (*The Launceston Examiner* 24 Sept. 1853, p. 999). This gathering, chaired by William Henty, resolved to approach the Council of the Royal Society in the capital to explore the possibility of setting up a branch. Permission was duly granted and the first assembly in the north, convened on 28 October, saw the election of officers and membership proposals forwarded to the southern headquarters for approval (*The Launceston Examiner* 27 Sept. 1853, p. 1011; 22 Oct. 1853, p. 1; 15 Nov. 1853, p. 78). Appointed as Honorary Secretary was R.C. Gunn (*The Launceston Examiner* 17 Nov. 1853, p. 1).

Unfortunately, the minutes of the earliest meetings of the Northern Branch have not survived, however, reports often appeared in the local newspapers and these accounts contain interesting snippets of information that do much to reveal intentions as well as activities. The group initially decided to meet monthly at Franklin Lodge; meteorological instruments recently arrived in the island were to be forwarded from the capital and observations taken in the Launceston Horticultural Society's gardens; the donation of specimens of minerals and curious coins was acknowledged; and noted was the need for presses and other equipment to form the nucleus of a museum. The year 1856 was significant for the purchase of a Tennant's geological cabinet with an assortment of minerals, rocks and fossils, a prestigious acquisition that caused much excitement amongst colleagues (*The Launceston Examiner* 8 May 1856, pp. 2–3; 29 Dec. 1857, p. 3) (plate 2).

EXHIBITIONS

Members in the north also found themselves being swept up in wider global matters. The nineteenth century had seen a flowering and popularisation of international exhibitions and world fairs centred around industry and culture. Parliamentary proceedings indicate the Tasmanian Government was content to leave the showcasing of the island's products at these events to the Royal Society and allocated funds accordingly (*Colonial Times and Tasmanian* 29 April 1854, p. 2). Both north and south responded by forming committees to consider, collect and forward items to France for the Paris Exhibition (*The Launceston Examiner* 28 Mar. 1854, p. 2; 20 Apr. 1854, p. 2; 4 May 1854, p. 2). A report of the Tasmanian Commissioner to the Paris Exhibition reveals the exhibits comprised of ores and minerals, wheat, wool, flour, Tasmanian wood (both in plank and manufactured form) and cabinets of algae and insects attracted much interest. It also drew the attention of Professor John Wilson, the Director of Raw Produce from the Crystal Palace, now relocated to Sydenham after its spectacular success as an exhibition venue at Hyde Park in 1851. His letter written in September 1855 requesting samples from Tasmania for display was reproduced in the press and Launceston members soon found themselves deliberating on their contribution (*The Launceston Examiner* 21 Feb. 1856, p. 2). Although Wilson listed minerals, vegetable and animal products as being desirable, he had also noted the value of maps, diagrams, pictures or anything else that would illustrate the colony and its potential. The success of an artwork depicting Hobart Town at Paris led the Northern Branch to concentrate on the attracting of immigrants to the colony. Thus, in September 1858 it was resolved to commission a painting of Launceston and an advertisement was duly formulated seeking artists to

PLATE 2 — Tennant's Geology Cabinet (QVM:1957:40:11). James Tennant (1808–1879), renowned mineralogist to the Queen who ran an import and dealership in shells, minerals and other items from his London address, specialised in the preparation and sale of educational boxed sets of geological specimens. Those that have survived are his legacy. The cabinet shown here is in the collections at QVMAG. (Photograph: David Maynard, Senior Curator Natural Sciences QVMAG)

present sketches of a scene. The successful contender was John McKirdy Nelson, and in February 1859 his view of Launceston and the valley of the Tamar from Westbury Road was completed and shown to members at Franklin Lodge (*The Launceston Examiner* 9 Sept. 1858, p. 1; 21 Oct. 1858, p. 2; 17 Feb. 1859, p. 3; *Cornwall Chronicle* 18 Sept. 1858, p. 4; Kerr 1992, p. 566). After being displayed to the public at the Cornwall Assembly Rooms, it was sent to Hobart Town to be exhibited before being shipped to England at the end of June on the *Isabella Brown*.

THE FIRST BRANCH WITHERS

Despite these signs of vitality, newspaper reports of the activities of the Northern Branch were dwindling towards the end of the decade. According to the memoirs of Henry Button, former Mayor of Launceston, written near the end of his life, the first Northern Branch had become defunct by the 1850s and he was part of an attempt to revive it in the early 1860s (Button 1909, pp. 314–316). His recollections have tended to muddy the waters surrounding the history of the Branch and some clarification is necessary. As spasmodic notices and accounts of proceedings can be found in the local press throughout the 1850s, it appears Button is mistaken. It could be said, however, that a brief revival occurred around 1862 when members set up a museum, mainly of specimens of geology and mineralogy, in an upper room of the recently erected public buildings in St John Street (plate 3). A precious fragment of the minutes of the meetings held there has survived detailing some of the arrangements for the display (plate 4). Despite this, maintaining supporters and momentum became difficult and sometime during the 1860s the struggle was lost, and the Northern Branch became defunct. The museum remained as its legacy until 1879 when the Launceston Mechanics' Institute, busy establishing its own museum, retrieved the remaining items and purchased the exhibition cases (QVMAG Records Launceston Mechanics' Institute).

Solomon Walker-Bowd in his thesis on the history of the Northern Branch has identified some of the causes for its early failure including the departure of Sir William Denison as Governor, gold rushes on the mainland leading to subsequent emigration, the Depression, and the demographic breakdown of the north that limited membership of such an elite society (Walker-Bowd 2013, pp. 8–10). Button acknowledges that the numbers were too small, and activities declined from want of attendance. Added to this were economic factors. Mention is made in January 1862 of the great number of subscriptions unpaid from the previous year and alternative sources of funding were being considered. Indications are that few new supporters were being admitted, leaving the small group of members to fall back on their own resources (QVMAG Minutes of RST Launceston Branch, 10 Jan. 1862). With its demise the intellectual gap was filled in the north by the Launceston Mechanics' Institute, a body that had been in existence since 1842 but whose focus was more aligned to working-class education (Petrow 1998, http://launcestonmechanicsinstitute.blogspot.com/p/v-behaviorurldefaultvmlo.html). More serious scientific endeavour was later boosted by the pursuits of the town's public museum (now known as the Queen Victoria Museum and Art Gallery or QVMAG) when it opened in 1891.

PLATE 3 — The public buildings in St John Street where a small museum was established in the upper rooms in 1862. (Photograph: L. Ross)

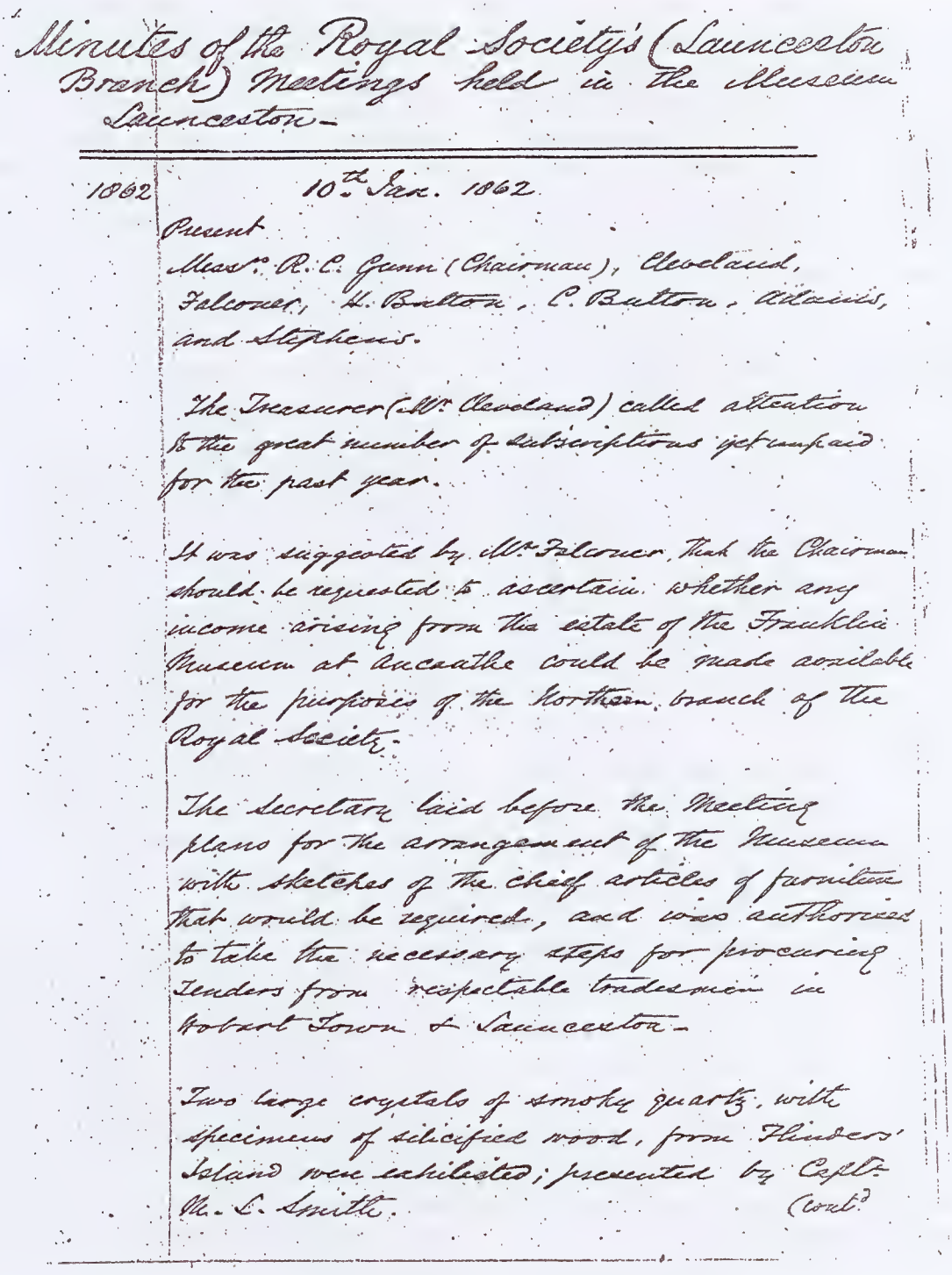
REVIVAL OF THE NORTHERN BRANCH

No further action was taken to revive interest in the Society in the north until early 1921 when historian, member of the Royal Society of Tasmania, archivist, librarian and government publicity officer, John Moore-Robinson, visited Launceston to assess what records of historical significance could be found. To his surprise he discovered a wealth of material which prompted him to write a letter to *The Examiner* suggesting that either a historical society or a branch of the state's Royal Society be set up to encourage and provide opportunities for research. *The Examiner* embraced the cause, voicing in print a preference for an offshoot of the latter, as it agreed this would give a broader scope for scientific subjects and thus attract more support (*The Examiner* 28 Apr. 1921, p. 4, p. 8).

From that point on events progressed rapidly and decisively indicating that Launceston was more than ready for such a move. The formation of a Northern Branch was discussed by the Council of the Royal Society of Tasmania in early May and the idea was greeted with general approval. It was noted that due process, in accordance with the rules, needed to be followed but if the proposal was ever presented it would receive the support of all members (*The Examiner* 11 May 1921, p. 4; *The Mercury* 28 May 1921, p. 6). 'Due process' required nominated persons to join the Society and then formally request that a branch be established. The Council also observed that although membership had recently increased during the post-war years, this would give a welcome boost to numbers and strengthen the whole organisation. (Newspaper reports indicate the membership numbered 82 in 1917 but with the increase since and the additional numbers from the establishment of the Northern Branch, the figure would reach around 200.)

On 11 May, a group of interested citizens met in Launceston and decided to arrange a further gathering of invited participants to assess the level of enthusiasm. This took place on 18 May where it was proposed that a branch be formed, and the proper steps be taken to carry it into effect. The motion, put by H.H. Scott, Curator of the town's museum, was seconded by the Launceston member for parliament, the Honourable T. Shields, and then carried. Many of those present were nominated for membership with more following suit in the days after (*The Examiner* 19 May 1921, p. 8; *The Mercury* 28 May 1921, p. 8). To hasten proceedings, at the end of May the Royal Society convened a special general meeting in Hobart to deal with just under 40 nominations from Launceston.

The last step was taken on 10 June when members, most of whom were new, passed a resolution that a Northern Branch be created. A request was sent to the Royal Society



Minutes of the Royal Society's (Launceston Branch) Meetings held in the Museum Launceston –

1862 10th Jan. 1862

Present

Messrs. R. C. Gunn (Chairman), Cleveland, Falconer, H. Button, C. Button, Adams, and Stephens.

The Treasurer (Mr. Cleveland) called attention to the great number of subscriptions yet unpaid for the past year.

It was suggested by Mr. Falconer that the Chairman should be requested to ascertain whether any income arising from the estate of the Franklin Museum at Ancaster could be made available for the purposes of the Northern branch of the Royal Society.

The Secretary laid before the Meeting plans for the arrangement of the Museum with sketches of the chief articles of furniture that would be required, and was authorised to take the necessary steps for procuring Tenders from respectable tradesmen in Hobart Town & Launceston –

Two large crystals of smoky quartz, with specimens of silicified wood, from Flinders' Island were exhibited; presented by Capt. M. C. Smith. (cont.)

PLATE 4 — Minutes of Northern Branch meeting held 10 January 1862 (copy held in the QVMAG Community History Room). (Photograph: L. Ross)

in Hobart and permission was given for the formation of a branch with the headquarters in Launceston on 13 June. At this meeting it was also resolved to send a letter to Mr Rolph, proprietor of *The Examiner*, thanking him for his hard work leading to its establishment (*The Examiner* 11 June 1921, p. 8; *The Mercury* 14 June 1921, p. 8). Meanwhile, with due process now completed on the 10 June, northern members turned their attention to the official opening and first lecture, an event they wished to stage on the earliest convenient date before the end of the month.

At 8 pm on 27 June 1921 the inaugural meeting of the new Branch was held at the Launceston Mechanics' Institute. The Secretary of the Royal Society, Clive Lord, outlined the history of the organisation and the Governor

of Tasmania, Sir William Allardyce, opened proceedings to an audience of members and the public with a speech that time has shown to be nothing less than prophetic.

> *"In a new land there is no limit to the possibilities of research. Tasmania is a country of infinite resources and of immense possibilities. Only the fringe of them has yet been touched. There is much of interest in regard to its past. There is even more of usefulness as well as of interest in the investigation of what its people can make of its future. Launceston is the centre of the mining industry of the state. For the present that branch of activity is rather under a cloud, but it is not always going to be so. Launceston is the headquarters of the geological survey. Thus, in geology alone there is a most promising opening for "the advancement of knowledge." Many other "ologies" could be mentioned. There is no end to them nowadays. As to what the branch will take up with most enthusiasm depends largely upon the types and the tastes of its membership. In the selection of a committee the aim was, and wisely, to make it as thoroughly representative as possible of the varying interests. The new branch commences its career under the happiest auspices. We can only express the hope that it will realise the expectations of its founders. It is seventy years since the first attempt at a northern branch of the Royal Society was made. It was long before its time. The branch soon withered and died. The conditions are now very different. What in 1853 was impossible should to-day be quite easy of accomplishment. And so we believe it will be found."* (*The Examiner* 28 June 1921, p. 4).

A paper, illustrated by specially prepared lantern slides and maps, was then read by the government geologist, Loftus Hills. The subject, of which he had first-hand experience, was the application of science to war on the western front with special reference to the secret of the Messines mines and the conquest of the German submarine by science (*The Mercury* 13 Sept. 1921, p. 6). During the first year, lectures were given on a variety of subjects including astronomy, psychology, evolution, exploration and the scientific application of the stereoscope. Members also threw their efforts into the attempt to establish Cradle Mountain as a national reserve and oversaw the public meetings held in Launceston to support this movement.

MUSEUMS – FROM PRIVATE TO PUBLIC

Nineteenth-century collectors in Tasmania were almost solely focused on the natural sciences such as geology, botany and zoology with the emphasis on describing, naming and cataloguing the many new species being discovered. A small number of these collections evolved into the earliest museums, albeit they were privately run with admission fees often charged. In the south, the largest institution was that owned by the Royal Society of Tasmania with a building being erected in 1863 to house the collections. In 1885 this museum passed into the hands of the government and later became known as the Tasmanian Museum and Art Gallery (TMAG).

In Launceston, the Northern Branch had brought together items, including a small library of scientific works, with the intention to create a museum as in the south. This assemblage, mainly consisting of geological and botanical specimens, was transferred to the newly erected public buildings in 1862. Surviving minutes of meetings dated that year give some details of the setting up of this museum, including the purchase of display cases. A library was also established in the building at the same time indicating the public nature of this structure.

In 1879 the Launceston Mechanics' Institute investigated the Northern Branch museum as they were resolved to establish their own. This organisation, with the help of the Royal Society of Tasmania, had also accumulated objects since its inception in the 1840s. To their dismay it was discovered that although the Tennant's geology cabinet was still present, many of the other items were missing. They purchased the display cases, and any remnants of the old museum were doubtless incorporated into the Mechanics' Institute collection at this time. Originally the Mechanics' Institute utilised the same room in the public buildings, but this proved to be a short-lived measure, and by January 1881 the exhibits had been relocated to their own building where a wing was later built to house them.

With the completion of a purpose-built museum in 1891, the Mechanics' Institute handed the contents of their own repository over to the Launceston City Council to form the basis of the collections at QVMAG. The evidence indicates the display cases initially purchased by the Northern Branch, and then by the Launceston Mechanics' Institute, were passed on to QVMAG.

During the twentieth century, many of the curators at QVMAG were members of the Royal Society of Tasmania, including the first, H.H. Scott, renowned for many achievements including his contribution to the study of Tasmanian megafauna. The Northern Branch formed in 1921 created even firmer ties with QVMAG when it moved from the Launceston Mechanics' Institute to the museum in 1937 where meetings have been held ever since, for many years at Royal Park and latterly at the new site of Inveresk. The Northern Branch has continued to foster a strong and close relationship with the museum, something exemplified by the centenary gift in 2020 of a cabinet to house the recently donated Knight-Lambkin butterfly collection.

CONCLUSION

The history of the first Northern Branch and its contribution to the intellectual landscape of nineteenth-century Tasmania has not been widely recognised. Although in existence for only a short period it played its part as a precursor in the attempt to establish a scientific body in the north of Tasmania for an elite group of educated amateur scientists eager to study and understand the wonders of the natural world that surrounded them. Additionally, while the connection

between the Royal Society museum and TMAG in Hobart is well-defined, the situation in Launceston has been more obscured. As has been demonstrated, historically the development of public museums in the north during the nineteenth century reveals there was an evolutionary chain linking the Northern Branch, the Launceston Mechanics' Institute and QVMAG.

Finally, the original Northern Branch established in 1853 has left its mark with its history perceived as fractured, often represented as a long sleep, followed by a reawakening. This reality has impacted on the arrangements for the centenary in 2021, when the Northern Branch celebrates not 100 years of existence, but of continuous operation.

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TYEREELORE AND STRAITSMEN: THE TRUE STORY OF TASMANIAN ABORIGINAL SURVIVAL

by Aunty Patsy Cameron

(with six plates)

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Much has been written, theorised and assumed about Tasmanian Aboriginal peoples and histories, but few representations of their life and culture have been recorded by the subjects themselves. This paper reiterates and expands on the conclusions drawn in previous work that tells the little-known history of the genesis of Tasmania's contemporary Aboriginal communities. The lifeworld and identity of the unique cultural group formed by the *Straitsmen* and their female Aboriginal partners, the *Tyereelore,* on the small islands of eastern Bass Strait, has remained virtually undisclosed in colonial narratives. They were entrepreneurs and shrewd traders of the surplus from the sea and land and in partnership they thrived despite the harsh environment and their precarious position in the socio-economic landscape. Against all odds, their joint skillsets, adaptability and resilience ensured the survival of their descendants today.

Key Words: *Straitsmen*, *Tyereelore*, Tasmanian Aboriginal history, Bass Strait islands, George Augustus Robinson.

INTRODUCTION

The first peoples of Tasmania and their descendants have been popular subjects of literary reportage and imagination from colonial times to the present day, and the oral histories about these people and places have been my legacy. However, while a plethora of historical narratives have been written about our precious old people – our founding mothers and fathers – their own voices have been largely absent from these accounts. As a proud Tasmanian Aboriginal woman directly related to the Pairrebeene/Trawlwoolway clan of northeast Tasmania I have dedicated many decades to redressing this oversight. There are, of course, many revisionary non-Aboriginal authors whose scholarship I respect. These include Stephen Murray-Smith, Henry Reynolds, Lynette Russell, Rebe Taylor, James Boyce and Lyndall Ryan, and I sincerely acknowledge their contribution to Tasmanian Aboriginal history in modern times. What this paper provides, which is perhaps more uncommon in the Tasmanian context, is the cultural lens through which the visual materials, stories and peoples are examined. As one of many descendants of the *Straitsmen* and their Aboriginal wives, I hope to do their remarkable story justice.

I am passionate about the Bass Strait islands and the history that has shaped those of us who are descended from the people who lived in these homelands. I grew up on Flinders Island within a strong extended community of relatives made up of grandparents, aunties, uncles and cousins. The old people called themselves *Islanders* and those who were not part of the Aboriginal diaspora, were known as *Outsiders*, who in turn called the Islanders *halfcastes*, *darkies* and *niggers* (Greeno 1984, p. 13). My grandfather Silas Milton Mansell was born on Cape Barren Island just a few kilometres from the main settlement known as *The Corner* (pl. 1). He was in his early teens when his mother, father and siblings moved to live at Trousers Point on Flinders Island. My mother Dulcie was born at Prickly Bottom on Cape Barren Island during the tin mining season of 1932. Grandfather Silas and his brother Uncle Fred worked a small tin mine at Lee River on the northern side of the island (pl. 2).

My grandparents talked about those early years when racial discrimination and prejudice were rife on Flinders Island. They also recalled stories collected during their lifetime, of the old people who lived and muttonbirded on the outer islands – their family connections, boat building and navigation skills. They told of seasonal activities continued over generations, including collecting Black Swan (*Cygnus atratus*), red bill (Oystercatchers, *Haematopus* sp.) and muttonbird (Short-tailed Shearwater *Ardenna tenuirostris*) eggs, harvesting muttonbirds, hunting wallabies for skins, making shell necklaces and mining for tin (Greeno 1984, pp. 5–14). These stories, and the rich historical and cultural heritage they contained, have been passed to me just as I have passed them on to my children and grandchildren.

THE EMERGENCE OF AN ISLANDER COMMUNITY

In *Grease and Ochre: the blending of two cultures at the colonial sea frontier* (Cameron 2011), the multifaceted dynamics are revealed that shaped cultural, social and economic relationships between the men who called themselves '*Straitsmen*' and the Aboriginal women who, of their own

1921 2021 THE ROYAL SOCIETY OF TASMANIA NORTHERN BRANCH

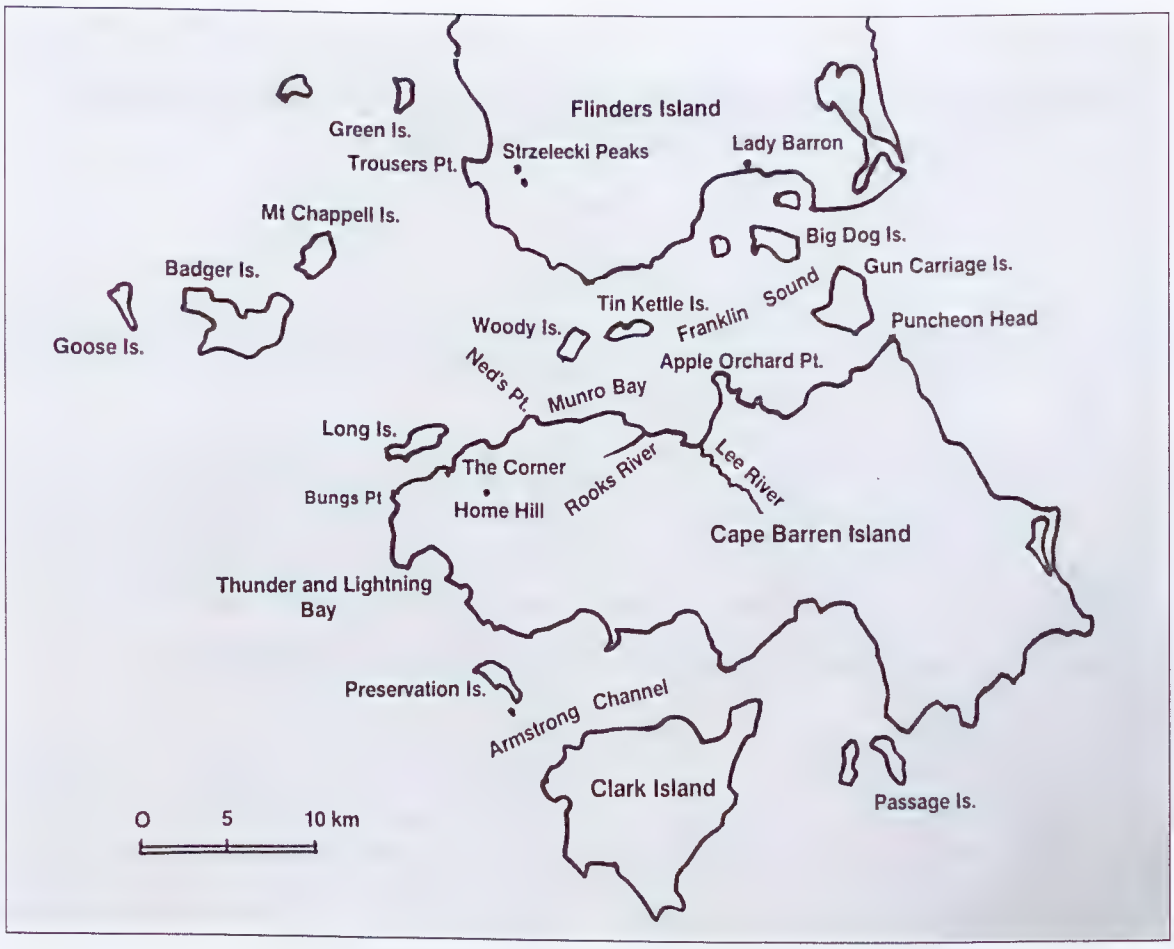

PLATE 1 — Map of the small islands of eastern Bass Strait referred to in this narrative including Preservation Island, Gun Carriage Island, Woody Island, Tin Kettle Island, Cape Barren Island and the southern part of Flinders Island. (Image from Greeno 1984, p. 9)

accord, called themselves '*Tyereelore*'. The title *Tyereelore* translates to *women of the islands* or *island wives*, which is insightful as it reveals how they saw themselves in the islander lifeworld. *Grease and Ochre* tells the story of these unique people and their lives on the Bass Strait islands during the first three decades of the 1800s. In it, several persistent assumptions/notions are interrogated and these are: that the group of men that identified as *Straitsmen* was a homogenous group of 'sealers'; that these men obtained Aboriginal women by kidnapping them from the Tasmanian mainland; that they treated them cruelly and brutally; and that these Aboriginal women were predominantly held against their will, having lost all cultural agency once taken to the islands.

Common knowledge is that *Straitsmen* were part of a larger group of mariners plying their trade in southern Australia during the early nineteenth century. They were labelled as lazy, drunken lawless miscreants, slave traders and abductors of Aboriginal women (Cameron 2011, pp. 71–111). Indeed, the Straitsmen were among these mariners on the sea frontier who filled a void after the professional sealers from Port Jackson left the straits for richer seal rookeries during colonial times. Some of these mariners continued to be engaged by wealthy fur traders in the colonial towns of Launceston and Hobart to undertake seasonal hunting of seals (*Arctocephalus* sp.) for skins and oil. Some were sinister hunters of Elephant Seals (*Mirounga leonine*) for their tongues and oil, while others were assisting convicts to escape the colony. While some were seasonal fur traders only a small group of men, the *Straitsmen*, chose to settle and make their permanent homes on islands in Bass Strait.

As for the Aboriginal women with whom the *Straitsmen* lived and worked, some had accompanied the men to the islands of their own free will, others were bartered by their clans for valuable commodities such as hunting dogs, and a few were taken against their will. If the portrayal that these women were subjected to such punishing savagery as concubines and slaves is accurate, it is hard to explain how, despite the harsh remoteness of living on the Bass Strait islands, many *Tyereelore*, including Pleenperenner, Pollerelbrener, Wyerlooberer, Teekoolterme (Nimeranna), Woretemoeteyenner, Tangerootairer, Emmerenna and Wotticowidger, had numerous children and raised them successfully on their island homes. These women and their families mastered the dual necessities of cultural change and continuity on the colonial sea frontier, and an examination of their lives is crucial to a more accurate understanding of Tasmanian Aboriginal history and survival.

PLATE 2 — Looking across from the site of the Old Township at the northwestern edge of Cape Barren Island to the Mt *Strzelecki* Peaks of Flinders Island. Long Island can be seen in the foreground. (Photo: Patsy Cameron)

RELATIONSHIPS NEGOTIATED

So much of Tasmanian Aboriginal historiography is connected to colonial government agent George Augustus Robinson's journal entries, transcribed and edited by N.J.B. Plomley in the mid-twentieth century (Plomley 1966). While there is no doubt that this volume is a very valuable source, the search for the voices of the ancestors is not dependent upon George Augustus Robinson alone, as there are many personal stories, reliable eye-witness accounts and clues embedded within colonial maps, paintings and sketches that illuminate scenes from the past. Using a combination of these sources, it is possible to delve forensically into this period in colonial contact history in Tasmania. However, in a departure from most well-known accounts, by approaching the *Straitsmen* and *Tyereelore* as emotional and social beings, rather than impassive historical figures, it is possible to provide a more sensitive and nuanced portrayal of their lifeworld. Through this same lens, the character, motivation and mission of George Augustus Robinson is also reassessed, with interesting results.

The story of Robinson begins when he was posted to Bruny Island by Lieutenant-Governor George Arthur in 1829 to take charge of the stores at the first Aboriginal Station established in Van Diemen's Land. Soon after Robinson took up his role on Bruny Island he received into his charge two *Tyereelore* who had arrived in Hobart on board the government brig *Prince Leopold* from Launceston. It was on 10 October when, at his house in Hobart, Robinson interrogated the two women, Mary and Fanny, to gather information about their lived experiences with the *Straitsmen* on the Bass Strait islands. In particular, he was interested in the 'slave traffic' in Bass Strait for he was convinced that:

> *"...this slave traffic is very common at the straits, and that the women so bartered or sold are subjected to every hardship which their merciless tyrants can think of and that from the time their slavery commences they are habituated to all the fatiguing drudgery which their profitable trade imposes. Surely this is the African slave trade in miniature, and the voice of reason as well as humanity loudly calls for its abolition. This information is further confirmed by the man Baker, who was himself a sealer in Bass's Straits and had for a considerable length of time cohabitated with the female Fanny".* (Plomley 1966, p. 82)

While interviewing Fanny Robinson, he noted that she spoke English fluently, had been baptised in Launceston by the Reverend Youl, and since moving to the islands had learnt from her husband, a Straitsman named Baker, the skills to navigate and steer a schooner and to row a boat. Fanny also told Robinson that there were about fifty women

in the islands and plenty of children. Robinson was aware that Baker had been charged for allegedly taking three women forcibly from Bruny Island, but the charge was dismissed because it could not be proven. In his appraisal of Fanny, Robinson judged her to be of middle stature, strong, very robust and of quick intellect. He also judged that both women had been subjected to hardship and drudgery as an indication of them being slaves (Plomley 1966, p. 82). Robinson failed to comprehend what life on the islands required from the men and women in order for their families to survive and thrive and mistook the markers of hard work and life battling harsh elements with those of slavery.

In response to Robinson's question about the slave trade the other *Tyereelore* woman he encountered in Hobart, Mary, also described her experience of clan negotiations with the *Straitsmen*. Mary stated that it was her people who agreed to the bartering of women with the *Straitsmen* in exchange for flour and potatoes. She had obviously resisted this exchange, for the *Straitsmen* had bound her hands and feet and took her away in a boat to the islands and that no attempt was made by her countrymen to 'rescue' her.

The barter or exchange of women in marriage was a traditional cultural practice of the clans. It was customary for young women to be taken away into the bush by a potential 'husband' and after a time if all went well, they returned as a couple (Plomley 1966, p. 83). Likewise, these traditional practices of exchange were practised on the northeast coast between the local clanspeople and the *Straitsmen*, who negotiated for women along customary lines. Agreements were made between the *Straitsmen* and local clansmen, including a clan headman Mannalargenna, who had bartered four of his daughters and a sister (Cameron 2011, p. 89). Meanwhile, in late 1829 Robinson prepared to leave Bruny Island to commence the trek into the remote regions of the island that Lieutenant-Governor Arthur had recently commissioned him to undertake.

ISLANDER LIFEWORLDS

Robinson started out from Bruny Island via the rugged west coast on the first of his so-called Friendly Missions. He would eventually make personal contact with the *Straitsmen* and *Tyereelore* at a number of locations. Robinson's arrival at several western Bass Strait camps offers valuable insights into the lives of the *Straitsmen* and their wives and provides evidence that certainly rebuts the myths that the men were a pack of drunken, lawless thugs and uncivilised brutes. Instead, what Robinson found would demonstrate irrefutably that the *Straitsmen* and their wives lived a sophisticated and civilised existence, and in doing so not only survived, but thrived on these remote Bass Strait islands.

The *Straitsmen* divided their seasonal hunting grounds, in which to harvest seal skins and oil, into geographical areas of western and eastern Bass Strait. When Robinson arrived on the northwest coast on the first leg of his Friendly Mission, he recorded being impressed by the scene of a *Straitsmen's* camp on Hunter Island. Three neat cottages thatched with grass were, according to Robinson, 'delightfully situated in a valley in which runs a stream of fine water' (Plomley 1966, p. 176). Robinson's sketch depicts a safe harbour, fenced gardens where he saw potatoes, turnips and cabbages growing, and a large puncheon full of seal skins, all of which should have been evidence enough of both hard work and a comfortable lifestyle (pl. 3). On the mainland opposite Robbins Island, Robinson described another camp with several cabins thatched with grass and a large number of kangaroo skins pegged out to dry. Here he met the headman John Witieye who was from New Zealand and whom Robinson considered to be 'very civil'. At this second site there were several *Straitsmen*, six *Tyereelore* and one Aboriginal lad, Tunnerminerwait, accompanied by about thirty hunting dogs, the use of which was adopted by Aboriginal people from the very early period of colonisation. Robinson was told by the *Tyereelore* that they had not been forced to live with these *Straitsmen*. Furthermore, in an ironic and embarrassing twist of fate, he was later rescued by them from drowning and taken to a camp opposite Robbins Island where he was fed, and provided with a change of dry clothes and a dry bed to sleep on (Plomley 1966, p. 176–181).

Robinson had a lot to be grateful for in terms of being rescued, and their generous hospitality, which included being given a much-needed supply of fresh potatoes and turnips from Hunter Island. On his departure from the camp the *Tyereelore* also presented Robinson with significant cultural gifts of shell necklaces and he in return gave them items of colonial society including glass beads, pincushions and buttons. However, in what might have been mistaken by those at the camp for a sign of mutual respect, Robinson seems not to have been simpatico, for his prejudiced view of the *Straitsmen* had blinded him from acknowledging their generosity, let alone their resilience to hardships and the abundant lifestyle they led. All the while Robinson was making 'observations' through prejudiced eyes and looking for every opportunity to confirm his belief that the women had been forced to live with them as slaves, and he continued to interrogate the *Straitsmen*, their wives and workers wherever he met them.

BANISHMENT FROM THE HOMELANDS

Another falsity common in public awareness of early colonial history relates to the form and circumstances of Tasmanian Aboriginal peoples' removal from their homelands on mainland Tasmania. Robinson had been commissioned by Lieutenant- Governor Arthur to circumambulate Van Diemen's Land and, through his 'tame Aborigines' or Aboriginal guides, make contact with the clans in the bush and convince them to place themselves under his care. This was a way that Arthur could appease the colonists by ridding the lands of the clans and thus allowing the colony to expand its economic intrusions onto the homelands without being attacked. As noted, Robinson referred to these endeavours as the 'Friendly Mission'. What follows highlights the lengths to which Robinson would go to achieve his aims.

PLATE 3 — Hunter Island *Straitsmen* camp sketched by G.A.R. Robinson in 1830. (Image from Plomley 1966, p. 163)

By October 1830, when Robinson's Friendly Mission arrived in Launceston, the colony was preparing for a military-style operation on the Aboriginal clans in the bush. In response to this, Robinson proceeded quickly to the northeast coast to make contact with the clans in that area. This incursion into clan country is very important to the narrative for it will explain more about Robinson's deceptive strategies to coerce the people into going with him and to understand why the people left their homelands. It will also raise the alarm for the security of the *Tyereelore* as they were put at risk by Robinson's intervention into their lives with the *Straitsmen*.

On 1 November 1830, with the help of his Aboriginal guides, Robinson located a small number of confederated clans inland from the Bay of Fires on Ansons Plain in the northeast of mainland Tasmania. This was a time when the military operation called the 'Grand Army' by Robinson (also known as 'The Line', and later coined the 'Black Line') was well underway. Robinson took advantage of the confederated clans' concern about unexpected encounters with armed parties in the bush, by telling them that if they did not accompany him, they would all be shot by the soldiers (Plomley 1966, p. 261). This was a deceitful move by Robinson for he knew that the military operation was far to their south, but his remarks caused the two clanswomen and five clansmen, including my ancestral grandfather Mannalargenna, to place themselves under his protection. This group became the first of the clans who were still free in the bush to leave their homelands and go to Swan Island under the assumption that their lives were in immediate peril instilled by Robinson.

Robinson needed to relocate the exiles further afield than Swan Island to prevent them from escaping back to their homelands. Robinson's deception was not simply opportunistic, it was pragmatic. He depended on his mission succeeding for it meant personal rewards in grants of land and money. Success would raise his status above that of a bricklayer, and wealth would bring social advantage to himself and his family. In seeking a more remote place for his exiles to be relocated from Swan Island, Robinson set out on a voyage of reconnaissance to the eastern Bass Strait islands. This voyage to the island homes of the *Straitsmen* was not only necessary in terms of finding the ideal location for his Aboriginal 'mission', but would give Robinson the opportunity to further interrogate the *Tyereelore* about their lived experience and for him to collect information on the character and economic situation of the *Straitsmen*.

ISLANDS OF PLENTY ON THE SEA FRONTIER

Robinson's voyage took him to Preservation Island, where he was greeted by old James Munro who had lived on the island for a decade. Munro was the same man Mary had earlier referred to as a good man who had provided the women and children with milk, vegetables, meat and bathing facilities. Mary had also said that Preservation Island was a good place and that it was better than what she had experienced during her short stay at the Aboriginal Station on Bruny Island. In response to Robinson's question about what he was seeking on this remote island, Munro stated that he had found

contentment living on Preservation Island (Plomley 1966, p. 269). Munro had obviously gained some respect from colonial authorities as he was appointed to the position of Constable as early as October 1825 so that law and order could be established in the straits. Munro was also respected by his fellow *Straitsmen* to whom he provided wise counsel when asked, although Robinson's view of him, revealed in his dispatches to the Governor, was at total counterpoint. The impacts of Robinson's arrival in the Bass Strait would soon become clear to the *Straitsmen* and their families and unsettle the serene lifeworld Munro described.

Munro had been among a number of professional sealers from Port Jackson working in Bass Strait in the late eighteenth century. When the majority left for richer sealing grounds around 1810, he and a small number of mariners settled on several islands in the Furneaux Group to carve out a living away from the colonial towns. Many of the *Straitsmen* resented being indentured to wealthy merchants in towns like Launceston and Hobart and had decided to shun colonial society for a life of freedom on the islands (Russell 2012, p. 105). As it would soon become clear, *Straitsmen* were not just hunters of seal but were also agriculturalists, seasonal wallaby hunters, boat builders, fishermen, miners of precious gemstones and traders of skins and surplus produce (Cameron 2011, p. 110, p. 121).

Henry Laing's sketch of Preservation Island evokes the memory of Mary and her portrayal of an abundant life on the island (pl. 4). The sketch reveals several neat homesteads snuggled among Casuarina trees located a short distance inland from a sheltered boat harbour. There are large fenced garden areas near the homesteads surrounded by grassy fields although the image does not include details of what vegetables and animals were present. Robinson identified animals in the fields including goats, rabbits, pigs and sheep, along with wheat, barley and potatoes growing in the gardens. At the time of Robinson's visit, Munro had three Aboriginal children in his care, all of whom were receiving instruction in the scriptures and learning to read and write. Although there was little acknowledgement of the significance of Munro progressing the children's literacy skills, Robinson could not deny it for he later witnessed a package of testaments and spelling books that had arrived on board a cutter from Hobart Town (Plomley 1966, p. 273). It is important to note that teachers of their children should be added to the list of skills of the *Straitsmen*.

On Woody Island, Robinson met old Gordy Robinson (no relation of G.A. Robinson), who was incapacitated after losing sight in one eye, along with two clanswomen, a child, and several domesticated dogs and cats. Gordy could not be accused of being lazy for he raised fowls, pigs, grew crops of grain and vegetables and prospected for precious gemstones. Between the numerous granitic outcrops on this small island, Gordy grew wheat as 'high as a man's head', as well as potatoes, onions and cabbages that covered about two acres of land. There was also an immense muttonbird rookery on the west side and an assortment of other bird species such as quail, magpies and moorhens which were in abundance, along with many large snakes. The old man Gordy had made good use of

PLATE 4 — A close-up view of Preservation Island sketched by Henry Laing in March 1831 that shows James Munro's cottages and large fenced gardens. (Image from Plomley 1987, pp. 98–99)

the carcass when butchering his pigs, boasting that he was the first in the islands to make bacon. While on Woody Island, Robinson took the opportunity to threaten the old *Straitsmen* stating 'The government was not going to treat with them (the *Straitsmen*) and it was well for him I came here or he would be cleared off the island' (Plomley 1966, p. 271). His wife Ploornelle had a small boy and Gordy was concerned for her to stay and care for him in his old age, a point that probably led Robinson to allow her to stay with him. However, he removed the other woman who he discovered to be Mannalargenna's sister, Toogernuppertootenner (Plomley 1966, p. 270).

The removal of Toogernuppertootenner may be seen as an opportunity for her to reunite with her kin who were with Robinson and that she would also be able to join her brother and other family members on Swan Island. Whatever her circumstances, she may not have had a choice. Robinson's motivation appears to be to remove as many of the *Tyereelore* from the *Straitsmen* as he can to appease his male exiles who were increasing in number on Swan Island. The following day Robinson set off for Gun Carriage Island where a large group of *Straitsmen* and their families lived.

In Plate 5, the colonial artist Henry Laing depicted Robinson's boat with sails still set anchored in Gun Carriage Island Bay seaward of the *Straitsmen's* boats. This island was much bigger than Preservation Island and Woody Island, and like the other two islands, contained a large muttonbird rookery. According to Robinson, there were eight cottages and several outbuildings with large fenced gardens where potatoes and peas were growing and goats, pigs and chickens roamed the grassy fields. Thomas Tucker was the headman and he lived there with his wife Worererkanner, whose nickname was Dumpe, and their young son, along with a number of other *Straitsmen* and their families. Robinson described this island as 'a delightful place' (Plomley 1966, p. 272).

The existence of Laing's careful depictions of these small island homes is extremely important as it enables us to visually critique the islands' lifeworld and, along with Robinson's descriptions, allows the voices of the ancestors to be heard. On close inspection of these drawings and paintings the islands can be seen as orderly and productive. Robinson himself presented the same visual descriptions of the *Straitsmen* and *Tyereelore* in his sketch of their campsite on Hunter Island and the mainland camp opposite Robbins Island. In that case, Robinson described a bountiful life with grazing livestock, fenced gardens, wooden huts neatly thatched with grass, thriving crops of wheat along with the production of up to twenty-five tons of potatoes and surplus supplies of cabbages and peas.

While, Robinson could not fail to be impressed by the mixed economy operating on the colonial sea frontier, he could not, or would not, acknowledge the economic partnership of the *Straitsmen* and their Aboriginal common law wives. His blindness to *Tyereelore* skill and agency is

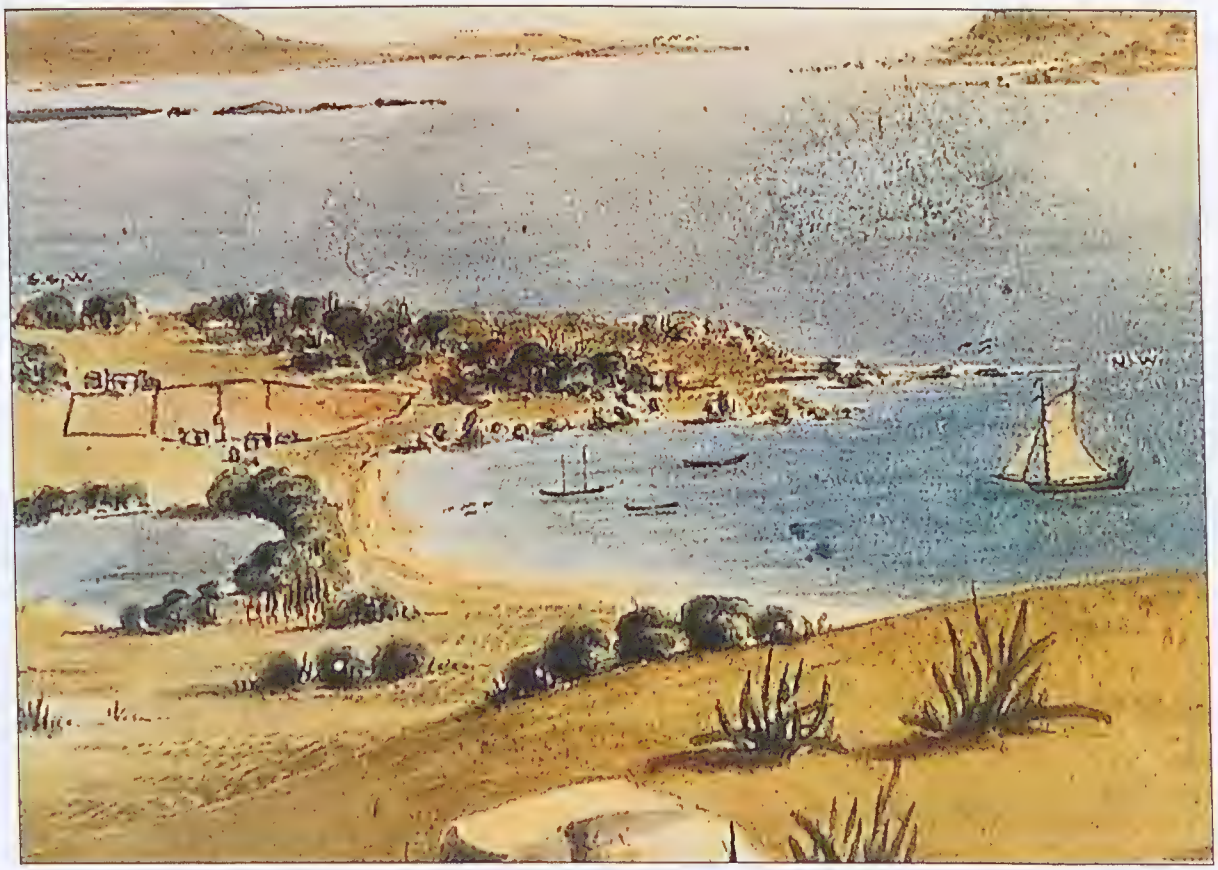

PLATE 5 — Painting by Henry Laing in 1831 from the hill on Gun Carriage Island looking west down Franklin Sound. Cape Barren Island is on the left with Woody Island and Tin Kettle Island in the distance. (Image from Plomley 1987, pp. 34–35)

evident in his assertion that 'The men cannot live by sealing alone and that they are dependent upon these slaves for their subsistence' (Plomley 1966, p. 295, p. 303). In fact, the *Tyereelore's* contribution was selective and instrumental. They did not tend European animals other than their many dogs, nor did they care for the vegetable gardens. They probably did not cook inside on kitchen stoves or clean the house for they were described as terrible cooks and dreadful housekeepers (Plomley 1966, p. 107). The *Tyereelore* contributed to the food supply by diving for crayfish and mutton-fish (abalone) on the rocky reefs. They looked after the muttonbird rookeries, collected eggs during the egging season and plucked hundreds of birds for their feathers and other products that were exported as an important commodity. They walked the beaches for favoured tiny shells, gathered mairreeners from the kelp at low tide, and cleaned and sorted them to thread into beautiful necklaces which they sent to colonial towns for sale. Robinson was given many strings of shells during his island visits but it is doubtful that he appreciated the effort of collecting and making these exquisite cultural treasures. As well as making shell necklaces the *Tyereelore* hunted wallabies for their skins, to sell in the colonial towns and gathered supplies of wild fruits to supplement the island diet. There was a division of labour between the women and the men although together they worked to harvest a surplus (Cameron, 2011, pp. 119–123).

ROBINSON'S CHARACTER EXPOSED

When Robinson left Gun Carriage Island, he took with him two more women. They exchanged presents and tokens with each other before their sad departure. In addition, when he returned to Swan Island in mid-November he sent his coxswain James Parish back to the islands to obtain more *Tyereelore*. As Plomley noted 'he must have realized that his settlement would not function successfully with too few women, even if he thought of them as housekeepers rather than wives. The idea of Aboriginal women as consensual sexual partners seemed to unnerve Robinson. According to Plomley he 'was a prude; he did not approve of the natives showing their sexual desires…' (Plomley 1987, p. 29). Whatever Robinson's reasoning, Parish took away eleven more women in December 1830. One can only imagine that the opportunity to join other family members on Swan Island sweetened the bitter pill.

Although I argue through this paper that the *Tyereelore* had agency over their lives with their *Straitsmen* husbands, Robinson's aspiration was to remove as many women as he could during this voyage, and his position as a government official gave him enormous leverage. His threats to evict families from their island homes if they did not comply were not idle ones. A few months after Robinson's reconnoiter to Gun Carriage Island, without any regard for the men, women and children who lived there, he sent in armed men to evict the families from the island. The cottages, sheds, paddocks and gardens were annexed for the second attempt to establish a suitable place for his increasing number of clanspeople who were accommodated on the smaller Swan Island.

Tragically, within a few months several of the people died from fever and dysentery including four women, Lucenermictic Wockerner, Ghoneyanener, Noendapper and her sister Walyer, and three males, Tarnebunner, Terlanderreener and Cowertenninner (Plomley 1987, p. 938). Furthermore, it was not long before Gun Carriage Island was found unsuitable to support the increasing number of people arriving there. A search for a more suitable location was undertaken and a place at The Lagoons, surrounded by wetlands and located above the beach on the west coast of Flinders Island, was chosen. The Lagoons, however, was also found to be unsuitable as the people were exposed to the westerly gales and drinking water was contaminated with salt. Eventually, in February 1833 the establishment was moved to Pea Jacket Point, later renamed Wybalenna (Plomley 1987, pp. 21–22).

When Gun Carriage Island was abandoned for The Lagoons in late November 1831, the *Straitsmen* and their families returned to their homes after nine months, but Robinson would not leave them in peace and his persistent interference in their lives continued to put the island families under stress. He eventually removed about seventeen *Tyereelore* from their husbands and children, which caused alarm among the island families. As a result of Robinson's actions, James Munro and Edward Sydney Mansell sailed their boat to Hobart and requested an audience with Lieutenant-Governor Arthur to put their case for the return of their wives. Arthur agreed that the *Straitsmen* and their children relied on the women for survival and he instructed Robinson that their wives should be returned (Calder 1972, p. 15). This decision by Arthur would have infuriated Robinson, and he continued to discredit the *Straitsmen* whenever he could. As a man who supposedly followed religious instruction, Robinson lacked empathy with the *Straitsmen*. He had no regard for the health and wellbeing of families on the islands, nor for their economic independence and survival. His main objective was to gain acclaim, increase his wealth and secure land that would come from his success with 'civilising' the people at the Wybalenna Aboriginal Establishment.

FIFTEEN YEARS OF COEXISTANCE

Over a period of fifteen years between 1832 and 1847 the Wybalenna exiles lived alongside the *Straitsmen* and *Tyereelore* families. During times of seasonal harvesting the people from Wybalenna walked around the base of Mt *Strzelecki* to Yellow Beach. They would light signal fires for the *Straitsmen* to bring the women and children to meet them to go muttonbirding on the islands in Franklin Sound. They also went on treks together along the east coast of Flinders Island to gather swan eggs during the laying season. Evidence can be found when viewing a map of Flinders Island drawn in 1832 by surveyor George Woodward who identified two sites located beside Camerons Inlet and Logans Lagoon where traditional (native) huts were built (pl. 6). These huts were

PLATE 6 — Map of Flinders Island drawn by surveyor George Woodward in 1832 depicts the location of traditional huts close to Camerons Inlet and Logans Lagoon (Image from Plomley 1987, p. facing 83)

built to shelter families from the outer islands during the period they came to Flinders Island to gather swan eggs and harvest wild ducks that bred and foraged on the wetlands.

It is important to acknowledge that seasonal hunting provided opportunities for gatherings where connection and reconnection between the Wybalenna exiles and Islander families took place. It is not difficult to imagine that stories and traditional practices would have been shared and passed on around the campfires as they sat under the stars. In 1833 during a trek to the east coast of Flinders Island, Robinson noted seeing evidence of hunting activity. Beside the lagoons he came across 'pegs sticking in the ground [in a place which] must have been …[a] favourite resort of the sealing women. Those pegs had been used for stretching out the wallaby skins' (Plomley 1987 p. 510). In concert, the evidence provided on Woodward's map, along with Robinson's records, is extremely important, as the close connections between *Straitsmen* and *Tyereelore* families and the people at Wybalenna is not one that has been proliferated in other versions, and its revelation adds a new layer of complexity to the colonial Aboriginal identity politics.

LOVING RELATIONSHIPS AND HEALTHY FAMILIES

In addition to the sketches, maps, paintings and written descriptions by Robinson there are two further accounts recorded by Europeans who had personal contact with the island families, that offer new insights into the remote lifeworld of the *Straitsmen* and *Tyereelore*. The first account was written six years before Robinson arrived in the straits. It was 1824 and John Boultbee had exhausted his finances while in Hobart Town. When offered a trip on a sealing vessel to Bass Strait he took up the opportunity of free food

and lodgings and the promise of adventure on the high seas. After spending several weeks riding out a storm off the northeast coast, the crew of the *Sally* dropped anchor in calm waters of Kent Bay on the southern side of Cape Barren Island. The sealing ketch was later joined by two whale-boats that pulled up alongside with about twelve men and a number of women and their dogs, on board. One boat was captained by Thomas Tucker from Gun Carriage Island and the other boat came from Preservation Island. Boultbee described the men and women all looking the same and smelling like foxes. The women were dressed in kangaroo skin frocks that were stitched together with the fur on the inside. The men wore kangaroo skin great coats with capes attached and they wore sandals on their feet also made of the skin of kangaroo. Boultbee wrote in his journal that the men looked like barbarians and they had boarded the *Sally* with confidence 'as if they owned it' (Cameron 2011, p. 107). Although their appearance was rough with their disheveled hair and bushy beards, Boultbee referred to the men as 'worthies' (Cameron 2011, p. 107).

The second account was written by John Lort Stokes during the years between 1839 and 1842 when Robinson was living in Melbourne and his influence in the islands had waned. Stokes was commissioned by the colonial governor to locate suitable sites for the construction of lighthouses that would ensure safe maritime navigation around the islands. Towards the end of his voyage, Stokes had the opportunity to spend time with the families living on the small islands. He observed that the men referred to their wives as their 'sweethearts' (Cameron 2011, p. 106). He found that the children were fine looking and healthy and the young boys were dexterous at throwing spears, adding that they would make fine harpooners on whaling ships (Cameron 2011, p. 110). The reports of Stokes and Boultbee are insightful. Boultbee saw beyond wild appearances, judging the men to be 'men of substance'. Stokes was impressed by the health and vigour of the children and his exposure of the fondness felt by the men towards their *Tyereelore* helpmates is both illuminating and extremely touching.

CONCLUSION

What my alternative reading of this crucial phase in Tasmania's colonial history reveals is a much more complex and insightful story than previous narratives have articulated. While some other historians, past and present, fail to emphasise or understand is the establishment of Aboriginal homelands on the small islands of Bass Strait and the true characters of those who built lives and economies there. These people, the *Tyereelore* and the *Straitsmen*, are tragically misunderstood.

The *Straitsmen* were not predominantly slave traders or miscreants as so often portrayed to be. Most were hardworking men and, despite their rough barbaric appearance, were entrepreneurs and shrewd traders of skins, feathers and surplus produce from the sea and land. The Aboriginal women who chose to work alongside them called themselves *Tyereelore* (*island woman or island wife*). They contributed to the island economy by harvesting muttonbirds and swan for feathers, eggs and meat, and collecting shells to make exquisite necklaces for sale and cultural purposes.

Together in partnership, the *Straitsmen* and the *Tyereelore* not only survived but thrived. They did so despite the harsh environment, their precarious position in the socio-economic landscape and the colonial government's campaign to steal the island women and evict the island families from their homes. Had Robinson succeeded, the present-day Tasmanian Aboriginal diaspora would not exist. This narrative honours the strength, tenacity, courage and resilience of those people – our ancestors.

ACKNOWLEDGEMENTS

I wish to thank all those who have enabled me to present this narrative on the unique and remarkable lifeworld of the *Tyereelore* and *Straitsmen*. In particular I thank my two referees, Professor Greg Lehman and Dr Rebe Taylor for their wise counsel in reviewing this paper, and sincerely acknowledge Dr Linn Miller, who has grounded and guided my enthusiasm from its inception. Permission to use the images was gained from D. Greeno and previously for publication in Cameron (2011).

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ASTRONOMY IN NORTHERN TASMANIA, 1920–2020

by Martin George

(with 13 plates)

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Tasmania has been the site of much astronomical activity over the past century. While most of the scientific research has taken place in the south of the state, this paper documents the significant activities that have been a focus in northern Tasmania, tracing the history of key events and people involved. The scene is set with a summary of pre-1920 astronomical history, followed by a detailed discussion of activities over the past 100 years, including the establishment of the Launceston Planetarium and its subsequent shift from QVMAG to the present-day Inveresk site. It identifies the many professional and amateur astronomers who have played a pivotal role in helping build Tasmania's strong astronomical reputation as a centre for research and education, now recognised worldwide. Many aspects of this paper are drawn from the author's own experience in the hopes of attracting further information to expand our knowledge.

Key Words: QVMAG, Launceston Planetarium, Astronomical Society of Tasmania, amateur astronomy, University of Tasmania, public astronomy, Tastrofest, Tasmanian eclipses.

PRE-1920 TASMANIAN ASTRONOMY

For thousands of years, the Aboriginal people of Tasmania have observed the night sky and watched the stars, the Milky Way, and Solar System objects. Some of their stories, handed down over generations, were learned and recorded by George Augustus Robinson in the 1830s. These showed, as examples, an understanding that the people recognised the bright and dark parts of the Milky Way, saw patterns in the stars, and were frightened by meteors (e.g., Plomley 2008, Gantevoort 2015).

Early settlement of Australia by people from elsewhere included, through both necessity and general research, astronomical and related observations. Tasmania was the site of the first known scientific research in Australia; in 1792, Elisabeth Paul Edouard de Rossel (1765–1829), rear admiral on Bruni d'Entrecasteaux's expedition, made magnetic measurements at Recherche Bay (Australian Heritage Database). The establishment of Rossbank Observatory in 1840, on the same site as the present Government House in Hobart, by Sir John Franklin and Captain James Clark Ross, enabled the commencement of detailed magnetic observations (Savours & McConnell 1982). Later in the nineteenth century, Tasmania was home to two prominent amateur astronomers. Watchmaker Francis Abbott (1799–1883) was transported to Tasmania after being found guilty of obtaining two watches by false pretences. He made detailed astronomical observations from Hobart, recording an aurora and many celestial objects. He wrote several papers and was especially interested in the star Eta Argus (now known as Eta Carinae) and its surrounding nebula (e.g., Abbott 1871). He also provided a time service for Hobart and kept important meteorological records, which were continued after his death by Captain Short at the newly established (1882) Hobart Observatory in Barracks Square (Orchiston 1992). One of Abbott's instruments, a Dallmeyer transit instrument that was later used at the Hobart Observatory, is currently in the collection of the Queen Victoria Museum and Art Gallery (QVMAG).

Alfred Barrett Biggs (1825–1900), a teacher, made many contributions to, and widely popularised, astronomy in nineteenth-century Tasmania. Biggs was especially interested in comets and the double star Alpha Centauri, and wrote many letters and papers, including for the Royal Society of Tasmania (e.g., Biggs 1887, George 2005).

After spending time in Bothwell, Hobart, Melbourne and then again Bothwell, Biggs moved to Campbell Town in 1872 where his interest in astronomy blossomed. On 9 December 1874 there took place a transit of the planet Venus across the face of the Sun, the first since 1769. (Note: Transits of Venus occur in pairs eight years apart, but the pairs themselves are separated by 105.5 and 121.5 years, alternately. The pair following the 1874 and 1882 transits took place in 2004 and 2012; the next will be in 2117 and 2125). Timings of these rare events were used to refine knowledge of the distance between Earth and the Sun, called the astronomical unit. (Note: Although transits of Venus assisted greatly in finding the astronomical unit, far more accurate methods were later used, including the use of radar to determine the Earth–Venus distance. Measurement of any one *absolute* distance in the Solar System reveals them all, as the *relative* distances are known independently of absolute measurement). Biggs assisted a party from the United States Naval Observatory (USNO) who observed the transit from The Grange, a property

owned by Dr William Valentine (c. 1808–1876), while another USNO party observed it from Hobart. To thank him for his assistance, Captain Raymond of the USNO presented Biggs with a photograph of the transit, now in the QVMAG collection. Later, Biggs pursued his astronomical interests in Launceston where he observed the transit of Venus in 1882 from the residence of Mr James Aikenhead at Windmill Hill, together with Reverend Canon Brownrigg (*The Mercury* 19 December 1882, p. 1; *The Examiner* 11 December 1882, p. 3; *The Examiner* 12 December 1882, p. 2).

Biggs established an observatory in the western part of the city and became known as Launceston's 'Astronomer Royal'. He had two observatory buildings: one was a roll-off roof observatory, and the other was the transit house left behind and given to him by the USNO Campbell Town party in 1874 (Orchiston 1983). However, there is some uncertainty as to the exact location of Biggs' observatory. A memorial to Biggs was erected in Launceston's Royal Park, at the presumed site of one of the observatory buildings, by the Northern Branch of the Royal Society of Tasmania in 1935 and unveiled on 18 September (*The Examiner* 18 September 1935, p. 7).

In 1857 the Royal Society of Tasmania proposed the establishment of an observatory for Hobart (*The Courier* 30 November 1857, p. 3). The proposal was received in England by Henry Labouchere, Secretary of State for the Colonies, who commented that the Royal Society was:

> *"expressive of their desire that Hobart Town should be selected as the site of any Astronomical Observatory which may be established in the Southern Hemisphere..."*
>
> *The Courier* 30 November 1857, p. 3.

The implication was that the proposal was for the establishment of a major observatory, but this did not eventuate. However, in 1882, following another deputation from the Royal Society of Tasmania, the abovementioned Hobart Observatory was established (Orchiston 1992) – an observatory of a kind less well-equipped than seems to have been suggested in 1857 by the society. This, and in particular, the establishment of the University of Tasmania in Hobart in 1890 and a bequest to the University by Arthur Leake of Ross for the establishment of a school of astronomy, were the preludes to the Hobart area becoming the main part of the state for astronomical research (Royal Society of Tasmania 1892).

What follows now is an account of the people and events in northern Tasmania that have formed an important part of Tasmanian astronomical history over the past century.

THE ASTRONOMICAL SOCIETY OF TASMANIA

Although formally based in Hobart, the origin of the Astronomical Society of Tasmania Incorporated (AST), a society of amateur astronomers, can be clearly identified from a letter written to Burnie's *The Advocate* newspaper published on 2 December 1932. It was written by Reverend Walter Walters of Scottsdale, the then Rector of St Barnabas Church at Scottsdale (Helen Chick pers. comm. 2009) and who is discussed in more detail later.

In his letter Walters began the process of forming such a society:

> *"Will those who are interested in the formation of a Tasmanian Astronomical Society or of a branch or section of some existing society to the same end please write immediately to the Rev. Walter Walters, The Rectory, Scottsdale. Those with telescopes should supply at the same time as accurate a description as possible of telescope, eyepieces, mounting, etc."*
>
> *The Advocate* 2 December 1932, p. 2.

By mid-1934 the AST was established and its first meeting was held in Hobart on 9 June 1934 (*The Mercury* 12 June 1934, p. 11). Although membership was concentrated in Hobart (where I joined the society in 1970), the AST had members across Tasmania, including in the north, as is still the case today (https://www.astas.org.au/). Following my arrival in Launceston in 1983 to take on managing the Planetarium at the Queen Victoria Museum and Art Gallery (QVMAG), membership in the Launceston area increased and over the past few years, a statewide AST gathering has been held at the Launceston Planetarium every September.

AMATEUR ASTRONOMY ACTIVITIES IN NORTHERN TASMANIA

There has been much interest in amateur astronomy in the north, independently of whether people have been involved with the AST. On 18 December 1985 there began semi-regular evening meetings of the 'Northern Observing Group', formed by several AST members who shared the common interest of making observations together in dark-sky locations. The first meeting was held near the Trevallyn Dam (Astronomical Society of Tasmania 1986) and since then meetings have been held at various members' properties or locations including Four Springs Reserve, near Selbourne; and Clarendon, a historic property south of Evandale. An active group continues today, informally known as the *Tamar Valley Astronomers* by the local members of the AST.

Since 1985, AST members have also played an important role at the Launceston Planetarium at QVMAG, running shows and assisting with public astronomy nights, and these activities are discussed further in a later section.

Since its inception in 2015, *Tastrofest* in Ulverstone has become a major yearly public astronomy and space-related event with displays, night sky observations and talks organised by Brittany Trubody and a keen group of local astronomy enthusiasts from the northwest of the state. Among founding partners was the AST, and the event is supported by the Central Coast Council, with a planetarium now being planned for Ulverstone, enthusiastically supported by Trubody and the Central Coast Council.

AST members have held many public astronomy events, including at Clarendon, Blackstone Heights and the

Trevallyn Nature Recreation Area. Many AST members in the Devonport area are active, and several are very keen on astronomical imaging. Notably, long-time member Peter Sayers has been involved in astronomy for many years and gives numerous presentations to schools and community groups. A fine example of the enthusiasm for astronomy in the northwest was the restoration of a 70-year-old telescope mount with a mass of about one tonne, which at one point was relegated to a scrap yard before it was found by AST member Harry Van Der Velde. Peter Sayers gave it to local master craftsman Kevin Walker, who has restored it beautifully and brought it back to full use in an observatory (Peter Sayers pers. comm. 2020, pl. 1).

There are other northern amateurs who should be mentioned individually, including Archdeacon Walter Walters (1892–1986), whose name appears in connection with the formation of the AST. Walters was Rector of St Barnabas at Scottsdale from 1927 to 1933, and it was while he was there that he suggested the formation of an astronomical society, as mentioned in the previous section (pl. 2). He was very keen on astronomy, and especially comets, and his telescope, dating from the nineteenth century, was donated to QVMAG. After a period in Bothwell, Walters returned to the north and lived in Latrobe from 1947 to 1960 before moving to East Devonport. He was well known wherever he lived and would often set up his telescope on the lawn at his residence in Hamilton Street, Latrobe (Robert Walters pers. comm. 2005.)

Over the years several other interested people in the north, while not always holding membership of the AST, have pursued the hobby enthusiastically. For many years, the observatory dome of Neil Burrows was a well-known feature in Welman Street, East Launceston, and visible from many parts of the city. The observatory was 'taking shape' in January 1966 (*The Examiner* 7 January 1966, p. 3), and eventually housed a 14.25-inch-aperture Newtonian reflector telescope. To my knowledge it was then the largest amateur astronomical telescope in Tasmania and was assembled by Burrows using ordered parts. Although a very keen amateur astronomer, Burrows had no known connection with the Launceston Planetarium or the AST, and unfortunately, I never met him. By 2010 Burrows was no longer living at the premises, and the observatory building had fallen into disrepair (pl. 3). Burrows' family offered to sell the telescope to QVMAG; this was accepted readily, as the telescope was an important part of Launceston's astronomical history. It was dismantled onsite by QVMAG staff on 26 November 2010 and moved to QVMAG at Inveresk, but the observatory building could not be preserved, and it no longer stands.

PLATE 1 — Restored telescope mount in Devonport. (Image: Peter Sayers)

PLATE 2 — Archdeacon Walter Walters in 1974. (Image courtesy: *The Advocate*)

PLATE 4 — Mervyn Millward at his observatory near George Town, 2020. (Image: Mervyn Millward)

PLATE 3 — Neil Burrows' observatory in Welman Street, Launceston, in 2010 before it was dismantled. (Image: Martin George)

Amateurs in the north have also taken part in astronomical research. A notable example of such work is that of Mervyn Millward, who runs a well-equipped observatory in the outskirts of George Town (pl. 4). He has a good relationship with the University of Catania and the National Institute of Astrophysics in Italy and has been involved with such research projects as measuring the rotation of stars, and imaging of dwarf irregular galaxies. Millward also contributes observations of variable stars to the American Association of Variable Star Observers and is an expert in astronomical photography, a fine example of which is shown in Plate 5.

Other amateurs have contributed to research involving occultations, which are events where one body passes completely in front of another (other than during a solar eclipse). On 3 July 1989 the planet Saturn and its ring system occulted the star 28 Sagittarii. AST member and Launceston Planetarium volunteer Karenne Barnes joined me in making observations of the event from Launceston, during which the changes in light from the star took place as different parts of the ring system occulted it. These observations contributed to a large database of information gathered from the event.

Asteroids can also sometimes occult stars. Several attempts have been made to observe these in northern Tasmania, although to date there has been only one known 'positive' observation: the occultation of the star SAO 190531 by the asteroid Metis on 6 August 1989, observed by five astronomers: Launceston Planetarium volunteer Peter Daalder and me in Tasmania, and three people in New Zealand. This resulted in the first direct measurement of the diameter of Metis, whose cross-sectional distance at the time of occultation was 173.5 km (Kissling *et al.* 1991).

Many occultations of stars by the Moon have also been timed, and these have contributed to knowledge of the Moon's orbit. Although not being made at present, these observations have been sent to the International Lunar Occultation Centre in Japan, and the results and analyses published as yearly reports (e.g., International Lunar Occultation Centre 1988). Plate 6 shows a group of amateurs, including me, at an observing site near Campbell Town in 1988, when a grazing occultation of the star Antares was observed (George 1988). These events occur when only the extreme edge of the Moon passes in front of a star, and the star repeatedly disappears and reappears because of the presence of lunar mountains, valleys and crater rims.

PROFESSIONAL RESEARCH IN NORTHERN TASMANIA

Although some of the research mentioned already is 'professional' in quality – especially that of Mervyn Millward – mention must also be made of formal professional research. The University of Tasmania has operated two underground muon counters in northern Tasmania, both in Hydro-Electric Commission underground power stations. One operated at Poatina (pl. 7) between 1972 and 2008 (Humble & Duldig 2013) and the other was operated at Liapootah in collaboration with Shinshu University in Matsumoto, Japan, from 1991 for several years (Munakata *et al.* 1995,

PLATE 5 – The Rosette Nebula, photographed at Mervyn Millward's observatory. (Image: Mervyn Millward)

PLATE 6 — Amateur astronomers at Campbell Town in 1988, following the observation of a grazing occultation. From left to right: Martin George, Peter Daalder, Julie Harvey, Martin Harvey, Tim Parr, Karenne Barnes. (Image: Martin George)

PLATE 7 — Dr A.G. Fenton with the University of Tasmania's muon counter at Poatina in 2006. (Image: Martin George)

Humble & Duldig 2013). Muons are subatomic particles created by the collisions of cosmic rays (mostly protons) with our atmosphere, producing a 'cascade' of various particles. Neutrons are also produced as a result of this bombardment. Having detectors underground means that particles having energies only above a certain minimum are detected. A large database of detections was compiled, together with those from neutron counters and other muon counters in the south of the state, including one in a disused railway tunnel near Hobart. These data assisted in research as to the sources of the cosmic rays, their energies and their variations in intensity and direction.

When cosmic rays produce a large number of secondary particles, the effect is called an *air shower*. Another, related, northern installation was an air shower detector installed at Liawenee on the property of the Inland Fisheries Commission (Fenton et al. 1981, Humble & Duldig 2013) which operated from 1982 until at least 1990 (Fenton *et al.* 1990).

In 2006, 2007 and 2015, Tasmania was the location of choice for research on the dwarf planet Pluto by astronomers from the South West Research Institute in the USA. On each occasion the researchers needed to observe an occultation of a star by Pluto, in order to learn more about Pluto's atmosphere in advance of the flyby of the *New Horizons* spacecraft past Pluto in July 2015. Indeed, this is the way in which the atmosphere was discovered in the 1980s: the gradual dimming of the star's light was the tell-tale sign of an atmosphere. In 2006, observations were made from a location near Longford (pl. 8); in 2007 they were made from Musselroe Bay; and in 2015 from Bicheno. The Launceston Planetarium assisted with arrangements, with Chris Arkless and I providing or organising observation locations.

The Launceston Planetarium itself is a centre for historical research on astronomy, especially in relation to Tasmania. I have been lead author and co-author on several papers detailing the history of low-frequency radio astronomy in the state (e.g., George *et al.* 2017), and have contributed to historical research on astronomy in Thailand (e.g., Orchiston *et al.* 2016).

'PUBLIC' ASTRONOMICAL PHENOMENA OBSERVED FROM NORTHERN TASMANIA

Many astronomical phenomena are not specific to northern Tasmania, or even Tasmania in general, and are seen over a large part of the world. However, in addition to those already mentioned, many interesting observations have been made from this part of the state, some of which have been easily viewed by the public. One type of predictable phenomenon that is quite specific to one's location is a solar eclipse, particularly a central one. By 'central' is meant that the centres of the Sun and the Moon coincide, so they are seen in exactly the same direction in space.

Solar eclipses occur when the Moon passes between Earth and the Sun. It is a fascinating coincidence that the Moon and the Sun appear almost exactly the same size in our sky; this is because the Sun is about 400 times more distant than the Moon, but also about 400 times larger, meaning that their angular size is about the same. So close is this coincidence that because the Moon's orbit around Earth, and Earth's orbit around the Sun, are elliptical (oval-shaped), sometimes the Moon can cover the complete disc of the Sun and sometimes it cannot (even when the eclipse is 'central'). A total solar eclipse is one in which the Moon covers the Sun completely; the other type of central solar eclipse is called annular, meaning that the Sun is not covered completely and appears as a bright ring surrounding the silhouette of the Moon.

PLATE 8 — Eliot Young of the South West Research Institute (USA) observing an occultation of a star by Pluto in 2005. (Image: Jeff Regester)

Total or annular parts of solar eclipses can last only a few minutes, and they are rare from a given location because they are visible only along a narrow path across Earth's surface that is typically at most a few hundred kilometres wide. Far more common from any given place are partial solar eclipses, which are not central. So, it is possible for an eclipse to be total or annular from along a narrow path, but partial over a larger part of Earth. Any particular location will experience a partial solar eclipse every few years.

During the past century (1920–2020), there have been no *total* solar eclipses visible from anywhere in Tasmania. However, there have been four annular eclipses, two of which strongly favoured the northern part of the state. (However, in addition, an annular solar eclipse would have been visible briefly from the southern half of Macquarie Island, which is part of Tasmania, just before sunset on 11 September 1988). Firstly, there was an annular eclipse visible from far southern Tasmania on 7 March 1932.

It was the third of six central solar eclipses for Tasmania for the twentieth century, the two previous ones being the total eclipse of 9 May 1910 and the annular eclipse of 30 July 1916. In 1932 the northern limit of annularity passed just north of Hobart, but annularity occurred just before sunset, with the Sun less than two degrees above the western horizon. Clouds prevented viewing from Hobart; in any case, mountains and hills to the west of the city would have prevented any viewing from there. However, Launceston reportedly had a clear view (*The Mercury* 8 March 1932, p. 2) of what was a partial (not annular) eclipse, with 91.2% of the Sun's diameter obscured just before sunset.

On the afternoon of 14 January 1945, the path of an annular eclipse crossed parts of the northwest of Tasmania, with the event gaining coverage in all three major Tasmanian newspapers: *The Advocate*, *The Examiner* and *The Mercury*. The path from which annularity was seen was only about 27 km wide, which was relatively narrow, even for a central eclipse. The eclipse was so nearly total – with 99.4% of the Sun's diameter obscured – that the duration of annularity (the 'ring') was only 27 seconds. The central line of the eclipse entered mainland Tasmania on the west coast, about 18 km north along the coast from the mouth of the Pieman River, and exited through Cooee, near Burnie. Along the path of annularity, locations that experienced annularity included Takone, Yolla, Burnie and Somerset. The path also passed across the central part of Flinders Island, with Whitemark being close to the centre line. *The Advocate* reported that although intermittent cloud was present in northwestern Tasmania, the annular eclipse was 'witnessed', indicating that from some places there was a clear sky at the important time (*The Advocate* 15 January 1945, p. 2). A partial eclipse was also observed from Launceston and Hobart (*The Mercury* 15 January 1945, p. 4), and an annular eclipse was 'apparent' on most parts of Flinders Island (The Examiner 15 January 1945, p. 4).

The next central solar eclipse to be visible from Tasmania was that of 5 February 1981, but on that occasion, the north of the state largely missed out. The centre line passed through Lake Pedder and Cygnet, and the northern limit of annularity passed through Macquarie Harbour and Hobart. However, a partial eclipse, with most of the Sun covered, would have been visible from the northern parts of the state. Most locations in the south were clouded out.

The sixth and final central solar eclipse of the twentieth century to have its path cross Tasmania – yet another annular eclipse – was very much a northern event. It took place on the morning of 16 January 1991 when the centre line entered Tasmania just north of Marrawah on the northwest coast, and passed through Wynyard, Hawley Beach and Lilydale before leaving the coast just north of Scamander. The southern limit passed through Macquarie Harbour, Elderslie, Tea Tree and Nugent, with Hobart missing out on annularity. The path was so wide that it included all of King Island and most of Flinders Island. The Launceston Planetarium conducted a public viewing of the event, led by Planetarium volunteer Karenne Barnes. Images of the eclipse were projected safely onto screens set up on the lawn in Royal Park, and the 'ring' of annularity was witnessed by all. Although a popular event, the 1991 eclipse had rather less coverage of the Sun than that of 1945, with only 92.3% of the Sun's diameter obscured from Launceston. However, because of this, annularity was visible for much longer, being 6 minutes and 45 seconds in duration around the centre line.

During the twentieth century six central solar eclipses crossed the state (including those of 1910 and 1916), but the current century has none. The next will be a total solar eclipse, visible from the far northwest of the state on 25 June 2131.

Unlike solar eclipses, lunar eclipses are visible from any part of Earth from where the Moon is above the horizon, so they are visible from more than half of the planet. Nevertheless, these events, especially total lunar eclipses, are popular for all interested in astronomy. They are sometimes called 'blood moons' because when the Moon is immersed deeply or completely within the shadow of Earth, it turns a deep coppery-red colour because of light scattered in our atmosphere. These events have been well publicised by the Launceston Planetarium and have always attracted public attention. For the eclipse of 28 August 2007, a large crowd gathered at the QVMAG in Wellington Street, Launceston, for public observation of the event.

A phenomenon for which Tasmania offers good prospects for observing is the Aurora Australis, also called the southern lights. Aurorae occur in oval-shaped regions centred on Earth's magnetic poles, and are caused by charged particles from the Sun streaming through space and interacting with Earth's magnetic field; these particles and those already trapped in the field penetrate our atmosphere and cause it to glow. They are more common around the times of 'solar maximum' – peaks in the activity of the Sun that occur, on average, about every 11 years.

A question often asked is: Where is the best place to see the aurora? Although the southern parts of the state have a slight advantage over the north, the north does experience some fine displays, and sometimes more people in the north witness such events because there is less associated light pollution. The general answer to the question is to travel *south* of any town or city, to get the artificial lights behind the observer. So, for example, travelling from Launceston to Relbia or south of Evandale, or from Devonport to south of Spreyton, would enable a better view. The main point is to avoid being amongst, or to the *north* of, artificial lights. Plate 9 shows an image of the aurora taken from northern Tasmania.

Although the visibility of comets is not sensibly affected by one's location in Tasmania, many observations and fine images of comets have been made from the north, both by astronomy enthusiasts and the general public. By far the most spectacular comet of the past few decades was Comet McNaught, which was at its brightest in January 2007. Seen at its best from the southern hemisphere, it was even a fine sight from places with a considerable degree of light pollution, but because it was visible to the west after sunset, many Hobart residents would have been at a slight disadvantage because of some obstruction

PLATE 9 — A display of the Aurora Australis, photographed from Ulverstone on 10 September 2015. (Image: Martin George)

from kunanyi/Mount Wellington. Launceston, with less artificial light and generally lower terrain to the west, was the more favoured of the two cities, although any dark place in Tasmania with a clear sky and good view to the west and southwest offered an unforgettable experience. Plate 10 is a view of Comet McNaught taken from Nile Road, south of Evandale.

The first decade of the twenty-first century saw the occurrence of two transits of Venus across the disc of the Sun, in 2004 and 2012. These were the first such events since the pair of transits of 1874 and 1882 (mentioned earlier). Several public observation sites were set up in Tasmania for each event. Two major sites in northern Tasmania were the Queen Victoria Museum in Launceston and the showground at Campbell Town. Campbell Town was a key site because of the historical importance of the 1874 transit being observed from The Grange; the showground was chosen because of the better visibility of the sky from there.

Only the first part of the 8 June 2004 transit was visible from Tasmania, as the event started in the mid-afternoon. The Launceston site, set up by Chris Arkless of the Planetarium, was completely clouded out. Early in the day Campbell Town, where the event had been well publicised, experienced very dismal weather, with the sky completely cloudy and rain falling. A public gathering at the Campbell Town Library attended a talk about the transit presented by me, and an enthusiastic crowd later gathered at the showground, from where there were periods of clear sky, enabling observations.

On 6 June 2012 the Sun was above the horizon from Tasmania for the entire event. Both Launceston and Campbell Town had mostly clear skies, and much of the event was seen from both sites. In Launceston, more than 1000 people attended the session conducted by Chris Arkless, with assistance from Planetarium volunteers. I coordinated an event at the Campbell Town site which attracted about 350 people, including the then Premier of Tasmania, Lara Giddings.

A commemorative patch was made to celebrate Campbell Town's involvement in observations of the 1874, 2004 and 2012 transits. The next pair of transits of Venus will take place in 2117 (visible in its entirety from Tasmania) and 2125, when only the last few minutes of the event will be seen from here, just after sunrise.

QVMAG AND THE LAUNCESTON PLANETARIUM

The Launceston Planetarium, which forms part of the Queen Victoria Museum at Inveresk, is one of only eight fixed planetariums in Australia, although there are a number of portable ones. The following account of the Planetarium was drawn from my own experiences there since my arrival in 1983, and archival records at QVMAG.

Proposals for the establishment of a planetarium in Launceston – at QVMAG – began in 1955. On 13 April 1961 QVMAG Director Frank Ellis formally recommended to the Town Clerk that a Planetarium be installed and followed this up on 12 August of that year with a letter to the Northern Branch of the Royal Society of Tasmania seeking sponsorship for the establishment of a planetarium.

While this plan was being considered by QVMAG, optics manufacturer Carl Zeiss Jena, based in Jena in what was then the German Democratic Republic (East Germany), brought a Carl Zeiss ZKP1 planetarium projector (called a 'Medium-Type' projector) to the 1965 Sydney Trade Fair

PLATE 10 — Comet McNaught photographed from Nile Road, south of Evandale, on 21 January 2007. (Image: Peter Daalder)

for exhibit. It was subsequently purchased by the Adult Education Department in Hobart and used from November 1965 in the Adult Education Centre in Hobart for a short period. During the same month (November 1965), the 'Whole Council Committee' in Launceston agreed in principle to the establishment of a planetarium within QVMAG. The instrument cost quoted was approximately £6,000.

QVMAG suggested that the projector purchased by the Adult Education Department be shared between Launceston and Hobart, but this would have been an impractical arrangement. On 4 July 1967 the Adult Education Board in Hobart formally approved the projector and six-metre temporary dome to be 'transferred' to QVMAG for two years, but sometime after arrival, the agreement was made that it would remain at QVMAG permanently.

The Planetarium began operation on 30 January 1968 in the main QVMAG building in Wellington Street. QVMAG records show that the first planetarium operator was John Swift, who worked there until May 1974. An extension to the building was constructed, providing for a room to house the Planetarium in addition to a general-purpose theatrette and projection room. A fibreglass dome was installed in 1970 to replace the temporary linen dome. It was constructed by the Commonwealth Aircraft Corporation at Fishermen's Bend, Victoria, and is still in use today, at Inveresk. The ZKP1 projector was installed in the new room in April 1971.

While on a display tour, two significant NASA spacecraft were displayed briefly at QVMAG in the early years: the Gemini 10 capsule in 1967, and the Gemini 12 capsule in 1973.

There were several periods of closure of the Planetarium in the 1970s and early 1980s. Gordon Saunders ran his first shows in May 1978 and was officially given the role of Planetarium Officer on 1 July 1979. On 10 April 1981 QVMAG received the donation of a Skylark Rocket, which was hung in the rear stairwell at the Museum, where it was to remain until 2008 before being transferred to QVMAG's Inveresk site.

With the departure of Gordon Saunders around November 1982, QVMAG Director Christopher Tassell recommended a more formal staff position be established with appropriate qualifications. It was advertised and I was fortunate to be appointed to the position of Curator of Physical Sciences in March 1983, and running my first shows in April. As part of my work, I also became increasingly involved in promoting the Planetarium, and astronomy in general, in the media.

Up to 1983, the Planetarium had simply been known as the 'Planetarium at the Queen Victoria Museum and Art Gallery', a cumbersome name that I changed to 'Launceston Planetarium'. Although still sometimes called the 'QVMAG Planetarium', the name 'Launceston Planetarium' is now increasingly and more appropriately, used.

Before my arrival, the Planetarium had operated weekend shows, but during the period 1983 to early 1985 the QVMAG Director decided that these would no longer be continued. However, with the establishment of the 'Friends of the Museum', volunteers agreed to run these shows on Saturday afternoons. This gradually changed to become a group purely of experienced amateur astronomers, mostly from within the Astronomical Society of Tasmania, an arrangement that is still in place today. Current volunteers running shows are Peter Brake, Martin Harvey (who has volunteered since 1985), Mervyn Millward and Justin Young. Over the years, other volunteers have been Karenne Barnes, Tracey Bligh, Michael Booth, Lisa Coppe, Peter

Daalder, Trevor Leaman and Lisa Schmidt. In 1998 I became one of the founding members of the Australasian Planetarium Society, and since then there have been two annual meetings of the society held at the Launceston Planetarium (in 2004 and 2010).

The first major construction work since the 1970s began on 13 June 1999, when a new public entrance near the Planetarium's northern corner was constructed to replace the existing entrance near the eastern corner. At the same time an emergency exit was installed. The exhibit space nearest to the original entrance was converted into a Planetarium office, which provided a room for meetings and released space in the cove area of the Planetarium.

Several interested and capable Museum staff with astronomy, technical or teaching experience had been 'backup' staff members over the years, including Mark Gordon, Louise James and Tracy Muir. However, by 2002 staff member Christopher Arkless became officially assigned to the Planetarium on a part-time basis, his hours being divided between the Planetarium and information technology work. Today, all his time is dedicated to the Planetarium, and his technical and astronomical knowledge are invaluable.

The addition of this particular second staff member was especially important because of the increase in my own duties. I became a QVMAG manager in 2004, and in 2005–2006 I spent two years as President of the International Planetarium Society, an organisation with which I am still considerably involved in several capacities including as current Board Member for Oceania. In addition, from 2005 to 2014 I was administrator of the Grote Reber Medal for Radio Astronomy, the world's gold medal in that field. While this additional work was and is performed largely during my own time, it has been a positive outcome for QVMAG and the Launceston Planetarium; notably, the Grote Reber Foundation funded the 2009 purchase of the ZKP3 projector and establishment of the *Southern Skies* exhibition, both mentioned below.

In 2006 my membership of the International Astronomical Union (IAU) attracted significant media attention in Launceston when astronomers (including me) at the IAU General Assembly in Prague voted on a definition of the word *planet* that excluded Pluto, which became newly classified as a *dwarf planet.*

In 2001 QVMAG consolidated onto two main sites: the existing building in Wellington Street and the Inveresk Railyards, which had closed for railway operations in 1994 and been partly converted into a museum site. The subsequent decision in 2007 to convert the Wellington Street building into an art gallery necessitated the move of the Planetarium to Inveresk. The final show at the Wellington Street site was run on 29 February 2008, to a full house (pl. 11). A new room was constructed at Inveresk, and the dome and seating were moved to the new site. During this period, the Zeiss ZKP3 projector at the Stardome Planetarium in Auckland, New Zealand, was offered for sale and subsequently purchased by QVMAG. The Planetarium reopened on 12 October 2009, with a much-improved 'Zeiss ZKP3 night sky' and a digital fulldome projection system which allowed video 'movies' to be shown on the dome to replace the automated slide-based presentation that was used in conjunction with the ZKP1 projector (pl. 12). This arrangement continues today, with each presentation comprising a fulldome video show of typically 25 to 30 minutes followed by a live description of the current night sky using the ZKP3 projector.

A second ZKP3 was purchased from the Wollongong Science Centre and Planetarium in 2017, and the current projector is made up of parts of both.

A gallery space had been established in front of the Planetarium at Inveresk, and for three years after its opening in 2009 the Skylark Rocket and some photographs had been the only items on display. However, in 2012 a full exhibition was installed, entitled *Southern Skies: Astronomy in Tasmania* (pl. 13). It tells the story of astronomy in the state, including the work of the University of Tasmania, amateur astronomers and other researchers. Several of the objects on display were donated by the University, and the exhibition includes the Planetarium's original ZKP1 projector.

Although QVMAG did not retain complete attendance records for the Planetarium before 1983, since then and up to 30 June 2020 there has been a continuous record of 248,789 visitors; this number is the total of public shows, school group shows and shows for other common-interest groups. The two highest months on record were March and April 1986 because of the great interest in Comet Halley. From the incomplete pre-1983 records, it is estimated that there were 28,927 visitors during that period, bringing the best estimate for the total attendance to 30 June 2020 to 277,716.

The Planetarium has been involved in several internal and external astronomy activities such as public lectures and talks to common-interest groups. Stargazing evenings have been conducted at both QVMAG sites in conjunction with the AST, and daytime astronomy has been presented in Launceston's Brisbane Street Mall. Visits to schools (notably Youngtown Primary School) and school camps (including that at Waddamana) together with Planetarium volunteers have taken place. On several occasions, volunteers Karenne Barnes and Peter Daalder accompanied me on visits to Camp Quality near Avoca. One of the more unusual activities was my involvement with Trans-Australia Airlines as an astronomy commentator for 'Halley's Comet Flights' in 1986, one of which departed from Launceston and two from Hobart.

Among distinguished visitors to the Launceston Planetarium has been Dame Jocelyn Bell Burnell, in May 1999, who had discovered the first pulsar, in 1967. She also delivered a public talk at QVMAG.

CONCLUSION

Research in astronomy continues to grow in Tasmania, especially at the University of Tasmania, and by many AST members who are actively involved in public astronomy, and some in research, around the state. Enthusiasm for astronomy

PLATE 11 — The final Planetarium show at QVMAG's Royal Park site, 29 February 2008. (Image courtesy: *The Examiner*)

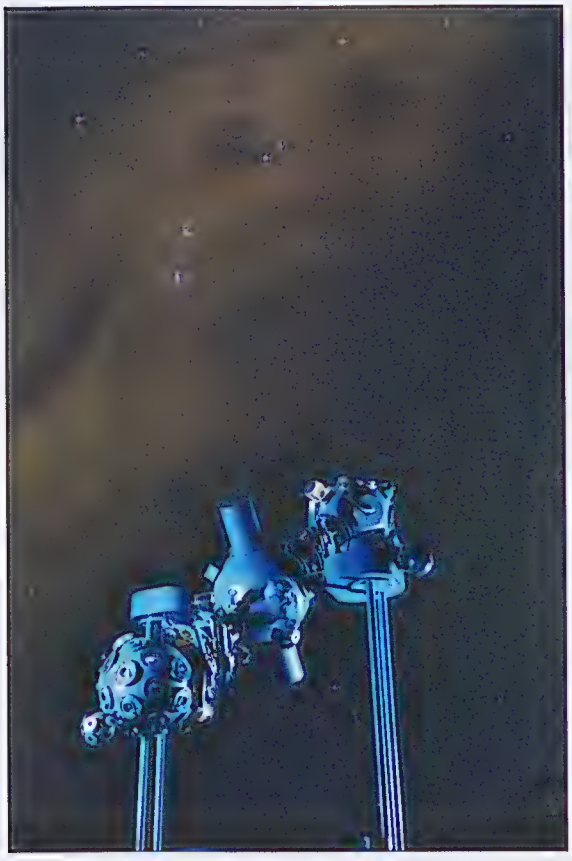

PLATE 12 — The Zeiss ZKP3 projector in operation in the Planetarium at Inveresk. (Image: Martin George)

PLATE 13 — The Southern Skies exhibition adjacent to the Planetarium at Inveresk, which opened in 2012. (Image: Martin George)

will surely continue in the north, aided by the increasing availability of state-of-the-art telescopes and imaging devices, together with great staff and volunteer expertise, all collectively contributing to education and research. Public astronomy, such as that offered by Planetarium visits, and stargazing evenings presented by the AST and the Planetarium, will always be popular as this continues to fire people's imagination about the sights in the sky and the exploration of space. Historical research, such as that undertaken in the preparation of this paper, will continue to add to this knowledge, including an understanding of Tasmania's contribution to the field of astronomy. As the author of this paper, I should be very pleased to receive any further historical information that may come to light.

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A ROCK IN A HARD PLACE: EUROPEAN USE OF DOLERITE IN TASMANIA

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(with fourteen plates)

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Despite being more prevalent in Tasmania than elsewhere, dolerite found relatively limited use by early European settlers. Dolerite was used in foundations, basements and retaining walls, but was difficult to shape and at least in the first half of the colonial century, highly unfashionable both in colour and texture, although acceptable for industrial buildings and rural outbuildings. Later in the nineteenth century, quarried stones of uniform colour were used to build some notable churches as well as basements for buildings of other materials. There was a progression during the three decades before the First World War from use of stones of varied size to a preference for stones of regular appearance; after which dolerite was largely replaced by concrete. For much of the twentieth century, dolerite was chiefly crushed for road metal, concrete aggregate or railway ballast, with occasional use in formal building. Towards the end of that period, it returned to building in decorative features, and to engineering practice as filling for gabions and in massive assemblies of boulders. This overview traces the use of dolerite in Tasmania from early colonial times to present-day practices in fashionable architecture and as a structural building material.
Key Words: dolerite, Tasmania, colonial architecture, structural material.

INTRODUCTION

If dolerite were a precious mineral, Tasmania would be as rich as a Gulf emirate, for the rock occurs over a greater proportion of this island than anywhere else on Earth. Wherever we live in Tasmania, it is likely that dolerite will form part of our lives. The landscape abounds with dolerite-topped mountains, and the rock appears at sea level in the spectacular cliffs of the Tasman Peninsula and Bruny Island and places like the Mersey Bluff. The dolerite top of kunanyi-Mount Wellington looms above Hobart, and the rock outcrops in the city, although less prominently than in Launceston where it forms the Cataract Gorge and the First Basin, and is the bedrock of Trevallyn and West Launceston as well as the suburbs beyond the North Esk flood plain (pl. 1). It is the prevailing road metal in many parts of Tasmania.

At least two-thirds of the surface area of Tasmania is dominated by basic igneous rocks or the products of their erosion, about a tenth of that chiefly basalt, and the remainder dolerite. A foremost authority on dolerite, David Leaman, wrote of it as 'The rock which makes Tasmania', but also recognised it as 'Tasmania's curse' because of the difficulties it has caused, and continues to cause, the mining and agricultural industries and the builders of infrastructure (Leaman 2002).

Petrologists named dolerite *diabase, dolerite* or *microgabbro*; whereas builders called it *whinstone, traprock, bluestone* and *greenstone,* according to their place and tradition. In the north of England and the Scottish borders, 'whinstone' can mean basalt or dolerite, and in most writings of British origin that discuss their use in building, the two similar rocks are not differentiated. Both rocks have essentially the same chemical composition and mineralogy, differing chiefly in their crystal size because of the manner of their formation; basalt is extrusive and finer grained because of more rapid cooling of the magma, dolerite coarser because of its intrusive origin. The *Oxford English Dictionary* gives 'whin' as an Old Scandinavian word applied to prickly shrubs. 'Trappa', according to *Webster's Dictionary,* is Swedish for steps or stairs, and the word appears to allude to the forms of outcrops, and possibly came to North America with immigrant quarrymen. 'Greenstone' is a mainly American usage resulting from the high proportion of olivine in some deposits, as in part

PLATE 1 — Columnar jointed dolerite, part of a faulted mass exposed at sea level in the Cataract Gorge, Launceston.

1921 2021
THE ROYAL SOCIETY OF TASMANIA
NORTHERN BRANCH

of the old Cataract Hill quarry in Launceston, but most of it is blue-grey, and called 'bluestone', along with basalt, to the confusion of Victorian visitors for whom bluestone is always the latter. In Van Diemen's Land, Louisa Anne Meredith, watching the building of her home at Great Swanport, added to the confusion by calling it '*ironstone*', in inverted commas (Meredith 1852) probably referring to the rust-like surface of chemically-weathered stones, or the resemblance of freshly fractured surfaces to newly broken cast iron.

Mrs Meredith noted that in her district its jointing:

> *"...very conveniently separates it into flat slabs of all sizes and thicknesses, suitable for rough stone buildings, and when well fitted and cemented together, and neatly faced with cut freestone at all the corners, door and window case. &c., it makes a most substantial fabric."* (Meredith 1852)

It is not everywhere that dolerite conveniently separates into stones suitable for building; the widespread occurrence of *platy jointing* in the Swanport districts on the east coast accounts for a local prevalence of dolerite structures from the early colonial era, not matched in other parts of Tasmania. The best-known example is the 'Spiky Bridge' south of Swansea (pl. 2), but there are several houses and other buildings in the district (Ward *et al.* 2017, numerous references). Elsewhere, the most accessible is the Kerry Lodge Bridge on the old Main Road between Franklin Village and Breadalbane.

In many other places, the rock appears as massive columnar structures needing to be broken into stones of manageable size, and laboriously hammered or *knapped* into shape, or as rounded subsoil boulders unsuitable for building. Despite its prevalence and availability, the use of dolerite by the early European colonists was limited up to the time when manufactured materials came to dominate building in Tasmania.

PLATE 2 — The Spiky Bridge south of Swansea was built by convicts from the Rocky Hills Probation Station in about 1843, of platy-jointed dolerite from near the site with lime mortar and a coping studded with mini-columns.

A MINERALOGIST WITH TIME ON HIS HANDS

Adolarius William Henry Humphrey (1782–1829) was son and grandson of the leading 'commercial naturalists' in London, dealing in 'natural curiosities' such as insects, shells, fossils and minerals in demand for private collections. Adolarius showed a strong interest in natural sciences from childhood and in his youth attended courses in chemistry. In 1797, Governor Hunter requested the services of a mineralogist to assess the potential mineral wealth of the colony of New South Wales, aware that the French expedition under Nicolas Baudin had included two such experts. Matthew Flinders' expedition in the *Investigator* included a practical miner, but the influential Chamberlain to King George III, Charles Francis Greville considered that there was a need for 'a person with more knowledge than a working miner', as he wrote in a letter offering the position to young Adolarius (Currey pp 9–23 in Humphreys & Currey 2008).

Humphrey embarked on the ship *Ocean* at Gravesend in March 1803, accompanying the expedition intended to establish a settlement at Port Phillip. He arrived in October 1803 and in December, left the settlement at Sorrento on the schooner *Francis* with the intention to 'survey Van Diemen's Land and the islands about it'. The ship proved unseaworthy and near the Kent Group in Bass Strait he transferred to the *Lady Nelson,* carrying the commandant William Collins and the botanist, Robert Brown, who 14 years later was to be immortalised by his discovery of Brownian motion. They arrived at Port Dalrymple on New Year's Day 1804, and after some explorations around the harbour, they proceeded up the Tamar River, reaching the site of Launceston and encountering the Cataract Gorge on 9 January. On their return journey on 13 January, they went ashore to examine a waterfall at the head of an inlet that had been noted earlier by Matthew Flinders but not explored.

> *"We found it excellent water and filled several casks at it. While this was doing I amused myself with carving my name (A.H. 1804) in the solid Basaltic rock [...] with hammer and chisel, in a place where it must be seen by any boat's crew that may hereafter visit the spot for fresh water."* (Humphrey & Currey 2008, p. 60)

Collins named the inlet Supply Creek, a creek in England referring to a small tidal estuary and not a brook as in Tasmania today.

Near the falls stand the ruined dolerite walls of the Supply River Flour Mill built by Andrew Charlton in 1825. The isolated mill came under attack from Aborigines and bushrangers, and three successive millers were killed there, but it operated under various owners until 1882, and the wooden superstructure, two additional storeys high, lasted long enough to be photographed in about 1890. Two men who made their mark in Tasmania served their apprenticeship there in the 1830s and 1840s. Thomas Wilkes Monds (Monds 1907), builder and millwright, later the owner of the Carrick Mill, one of the largest dolerite buildings in the world, was a founding partner in the firm whose successor in Launceston still operates

the only commercial mill in the state. James 'Philosopher' Smith gave up milling and tried his luck on the Victorian goldfields and then as a farmer in Tasmania before becoming a mineral prospector. In 1871 he discovered the Mount Bischoff deposit that gave rise to what was for a time the largest tin mine in the world and a substantial source of the wealth that rebuilt Launceston in the era when dolerite was most in fashion.

BUILDING WITH DOLERITE

The earliest European rectilinear structures ever made in Van Diemen's Land were the borders of the garden made by Felix Lahaye during the visit of Bruny d'Entrecasteaux's expedition to Recherche Bay in 1792 (Jouffroy-Gauja *et al.* 2016). "By marking the boundaries of the vegetable beds with stone boulders and two square plinths in the centre, Lahaye aimed to transform a short-lived activity into a proven, long-lasting structure within the reach of future archaeologists" (Jouffroy-Gauja *et al.* 2016, p. 10). These arrangements of dolerite stones must have perplexed the Aboriginal people as much as their markings have continued to entice researchers to this day.

In the colonial century and up to the First World War, dolerite was used for foundations, basements and retaining walls, but seldom as the main material of entire buildings and those that exist are considered rarities in world terms. Most of the important examples were built in northern Tasmania, but there is also a special group in the Swanport district on the East Coast, with the material cautiously identified in a recent study as *rubblestone* or *fieldstone* (Ward *et al.* 2017, p. 18, p. 110), and scattered buildings elsewhere. In technique and superficial appearance, early dolerite buildings do not differ from those built of basalt, except that a few of the latter include shaped and smoothed stones, products of a labour that was never undertaken with dolerite.

Dolerite occurs in Hobart but was not the preferred building material because of the ready availability of excellent sandstone. In the presence of the fine colonial buildings around Sullivans Cove, it is readily forgotten that those on Salamanca Place and most of those on the former Hunter Island stand on dolerite. Most of the early production from the quarry at Battery Point, now largely occupied by Salamanca Square, was used to reclaim the foreshore to build the New Wharf, but the stone was included randomly in some nearby foundations in the 1840s, and used more formally in the *Fusilier Cottage* of 1840 (pl. 3). Later, it appeared prominently in a great warehouse built for Askin Morrison within the former quarry in the 1850s. The Scottish engineer, William Falconer who probably designed the building, also used dolerite extensively in his work for the Hobart Gas Company after 1852; some of which still remains, and many will remember the great roofless wall along Evans Street, now lost to road-works. *Brinktop* in Crelin Street, Battery Point, has a wing faced with dolerite with much exposed mortar that also dates from the mid-century. While other examples exist, the use of dolerite as a building material is far more readily seen in the north of the state.

PLATE 3 — Squared dolerite rubble and cut and droved sandstone with 'Aberdeen bond' construction in the Fusilier Cottage, Hampden Road, Battery Point, Hobart.

Most of the early dolerite structures in the north of Tasmania relied on natural jointing supplemented by some working with hammer and bolster to produce flattish faces and right-angled corner blocks. There was one outstanding example of extensive shaping of stones into squared blocks. The great bridge across the South Esk River at Perth was begun in 1836 to the design of Lieutenant William Kenworthy, Inspector of Public Works at Launceston. Parker's Roman Cement impregnated with linseed oil was specified for the mortar of the piers, an expedient that had been recommended by the author of the most ancient architectural text, Marcus Vitruvius Pollio, in the first century AD. Work was interrupted by flooding in the following year, but was completed by 1839, with nine semi-elliptical vaults. Two of these were destroyed by a flood in 1852, and in the reconstruction only one was rebuilt (Smith 1969, pp 56–58). The bridge stood with eight vaults until April 1929, when a major flood after harvest time carrying trees and haystacks turned the strong structure into a weak dam, resulting in its destruction. The remarkably regular stonework can still be seen in the remaining parts of the abutments, and a capsized mass including the springing of two adjacent vaults can be discerned in the river-bed downstream.

THE VAN DIEMEN'S LAND PHASE

Formal building in Van Diemen's Land began in the Regency period, and our early builders largely followed the Georgian-derived fashions in the British Isles. The desired external surfaces at that time were smooth or finely textured and of even colour, with mortar joints regular and minimal in thickness. These requirements could be met with freestone, high-quality brickwork, or stucco coloured and engraved to resemble ashlar stonework. Unless rendered over, dolerite would not serve this purpose. At *Haggerstone* near Perth, where the house and the farm buildings are superbly built of dolerite, the house alone was stuccoed, though this has been removed in recent renovations.

The application of local stone during the building process is done for practical reasons, but there are also aesthetic, philosophical, mystical and even nationalistic motivations for its use. Even in our time, when the economics of building compels the use of industrial materials, stone retains a prestige that may be expressed in foundation stones and sometimes in decorative features.

In Britain, William Wordsworth was among those who advocated the use of local stone for building in the countryside:

> *"... the house must harmonize with the surrounding landscape: [...] may it be said, 'Look at the rocks and those parts of the mountains where the soil is visible, and they will furnish a safe direction'."* (Wordsworth 1835, p. 78)

He admitted an exception for those parts of his beloved Lake Country where there is 'an over-prevalence of a bluish tint', but where it is 'enriched by the iron tinge, the colour [...] will be produced of itself by the stones hewn from the adjoining quarry, and by the mortar, which may be tempered with the most gravelly part of the soil.' (p. 78, 79). The poet would have approved of the weathered dolerite walls of Tasmania, but not of Henry Hunter's later application of the broken stone in his churches.

In nineteenth- and early twentieth-century buildings in Tasmania, dolerite appears in a number of guises, but when exposed on a public face of a building, a striking change in the manner of its use and consequently its appearance emerged in the 1860s, underlining a pervasive change affecting architecture and the decorative arts in the mid-Victorian era, when mouldings became heavier and more elaborate, textures became more emphatic, and colours stronger and often more sombre. The contrast can be clearly seen at the corner of Balfour and St John streets in Launceston where an old brick house of about 1830 with variegated platy dolerite foundations was replaced by a mid-Victorian house standing partly across the old foundation and a new one of quarried blocks (pl. 4). When used for foundations and basements, and for ancillary buildings, the vivid variations in colour on the flattest surfaces of stones taken from superficial deposits could be made visually acceptable by whitewashing, as can be seen today in such buildings as the 1835 Pilot Station at Low Head and the South Bruny Lighthouse of 1836, both dating from John Lee Archer's incumbency as

PLATE 4 — Contrasting dolerite stonework at the corner of St John and Balfour Streets, Launceston: at left, random crudely-coursed rubble with surfaces as found, circa 1840, at right, squared quarried blocks in regular twelve-inch courses, circa 1880.

Colonial Architect, or in a farmhouse like *Glendessary* near Evandale, built by Scots in 1838.

The Scottish preference for stone could perhaps be argued to be a national characteristic, and perhaps a nationalistic one. "Who in Scotland would build in brick when stone is to be had", cried Robert Nasmyth (Nasmyth 1989, p. 151). Scots were accustomed to building with *whinstone,* and for centuries the prevalent mode of building where this occurred was with roughly squared stones of random sizes laid with horizontal and vertical joints but not in regular courses. This was the case not only in the countryside but also in the Old Town in Edinburgh, where dolerite occurs along with basalt in the volcanic remnants within the city, the Castle Rock, Calton Hill, Arthur's Seat and the Salisbury Crags; the last is the most characteristic dolerite feature. At the dawn of the 'Golden Age' in Edinburgh, in 1763, the first residential square outside the old city walls was begun (McKean 1992, pp 61–62), and although the houses were built in the new Georgian style, some of them were built of assorted rubble stone including local dolerite, and not the elegant grey ashlar of their neighbours and the New Town on the other side of the city. In an endeavour to approximate the regularity demanded by the style, the masons in George Square resorted to 'Aberdeen bond', a way of laying squared stones in regular courses, associated with the use of granite in the Highland city and its hinterland. The historian of eighteenth-century Edinburgh, Mary Cosh, noting the appearance, commented that in the square:

> *"...the effect was demeaned by a relatively low, irregular north side, poorly finished in a chequering of blue whin [and] limestone."* (Cosh 2003)

Notwithstanding its antiquarian interest, the rugged material still appeared 'wrong' for the style, as it had to many of those who built in Van Diemen's Land. Aberdeen bond appears only twice in Tasmania, in sandstone at the back of the old Penitentiary Chapel in Hobart and in

dolerite and sandstone in the *Fusilier Cottage* in Battery Point (pl. 3).

England provided no real precedents. Only one village and its manor house are known to be largely of dolerite: *Craster Tower* in Northumberland now consists of a square fourteenth-century pele tower slighted to about half its height and crenelated in 1797 when domestic additions were made, augmenting some from the previous century. Craster, on the nearby coast, is a small fishing port with a quarry that sent dolerite kerbstones to London for over two centuries until 1937 (Historic England 2019).

In Georgian building in England, the exposure of rough stonework was an eccentric choice. Some exceptions that prove the rule, both in England and Tasmania, are called *Stone House.* The one at Deptford near London, built in around 1772 of a rough Kentish ragstone, owes its eccentricities to having been built for its architect. The one on the Esplanade at Perth in Tasmania, also unusual in a number of ways, was built in 1827 for the Reverend John Youl, and was possibly designed by Lieutenant Kenworthy, engineer of the Kerry Lodge Bridge and of the lost Perth Bridge. It now has no fewer than nine fanlights, stuccoed wings flank the main front, and the rubble stonework is not built to courses, but of random rubble with great variation in the size of the stones. In the earliest part, the mortar is *buttered,* trowelled to smooth the surface so that it covers the irregular edges of the stones, a type of construction more likely to be applied to farm buildings, where variegated surfaces with a lot of exposed mortar were commonly whitewashed. An outstanding example is the stone barn at *Clarendon,* with walls about 0.7-metre-thick, and some stones that would weigh over 500 kg (pl. 5). Dolerite weighs about 2.8–3.0 g per cubic centimetre.

Because of the difficulty of shaping the stone, very few buildings are entirely of dolerite; most have either brick or sandstone parts, particularly around openings and forming corners. Even where stones suitable for cornerings or lintels occurred, as at *Haggerstone*, sandstone sills were required.

Fireplaces in dolerite buildings were invariably lined with brickwork, as the stone exfoliates explosively when exposed to intense heat. In most cases the brickwork was continued to the chimney tops; exceptions are rare.

The use of stones in construction can be considered in a number of ways: whether they are used 'as found' or artificially shaped; whether they are laid with mortar, or 'dry'; whether they are laid at random, in courses, or otherwise; whether the courses are regular or irregular, horizontal or raked, whether the builders were skilled or not. Most people have some intuitive understanding about what will stand on what, but those with some training or skilled supervision work differently in ways that reflect their experience, and in our colonial era this was generally in some part of the British Isles.

Some of the crudest buildings of which there are remains were built of field stones with earth as mortar, and their durability depended on the adequacy of the bearing surfaces as the earth between them eroded. The most substantial remnants of this kind of building are those of the ice-houses on kunanyi-Mount Wellington, embedded in a buried scree slope, and built of found stones by convict labourers under the supervision of an officer of the Royal Engineers, Captain Charles Stanley, and an overseer named Burgoyne (de Quincey 1987), with walls 1.2 m thick and originally 2.3 m high, faced with carefully built stonework with an infilling of packed earth and stones.

PLATE 5 — Massive dolerite rubble construction in the stone barn at Clarendon.

Dry stone construction depends entirely on good bearing surfaces as horizontal as possible in as much contact with their fellows as possible and is generally confined to retaining walls or cairns. When small stones are used, stability depends on skill; the mass of larger stones is an asset, particularly for retaining walls.

Lime mortar was usual for most of the colonial century and has the advantage of allowing some movement between stones in response to minor foundation problems without serious cracks developing. The practice of building to courses was in part an aesthetic decision, but it was also a way of regularising the stresses in a wall and thus enhancing its stability. Courses one foot (approximately 30 cm) in height were usual, matching the standard height of sandstone blocks produced by convict stonecutters, as well as four brick formats of the common colonial size, the bricks being around 6 cm high, with mortar joints 6.4 mm thick, a brick format being the space occupied by a brick plus half the attendant mortar.

The appearance of rubble built to courses, particularly when the regular horizontal mortar courses are emphasised, is visually particularly satisfying when compared with the 'crazy paving' effect of stones laid at random. In nineteenth-century work, professional builders maintained a certain horizontality for structural reasons, even when they did not build to courses, but in the twentieth century, the adhesive strength of cement mortar allowed walls to be built or faced with stones of any shape or size, fitted together like a jigsaw puzzle, with a consequent loss of visual coherence.

For appearance and durability, the exposure of mortar was usually minimised if the stones were to be exposed, but if they were to be whitewashed or rendered over, the mortar might be *buttered* to cover the irregular edges. In later nineteenth-century work, buttering was commonly exposed where 'politeness' was not required, but often regularised with false joints made by grooving (pl. 6) or strap-pointing (pl. 7). The latter can be seen on the Carrick flour mill built in the 1840s with walls a metre thick and extended by Thomas Wilkes Monds in 1890.

PLATE 6 — Christ Church, Cullenswood, built in 1847: random rubble, crudely coursed, with weak lime mortar buttered and engraved.

PLATE 7 — Monds' Roller Mill, Carrick, built in about 1847 and extended in 1890: massive walls of dolerite, crudely coursed, surface mortar buttered and strap-pointed.

HOLY DOLERITE

The medieval preference for building churches of stone has often been related to the Christian faith and the reference to the disciple Peter as 'a rock' or in fact the proneness of wooden buildings to destruction by fire. The Church of England with an inheritance of medieval stonework was content to build in brick or stone throughout the seventeenth and eighteenth centuries, but the ancient insistence on stone reappeared strongly in the nineteenth century with the medievalising doctrines of Augustus Pugin and the Ecclesiologists, and the prominent use of dolerite in churches in northern Tasmania can be attributed to these opinions.

The earliest building of dolerite raised for worship in the colony was the chapel at *Entally* near Hadspen, designed by the Colonial Architect, John Lee Archer, and built for Archdeacon Thomas Reibey in 1835 (Smith 1962). The house, stables and coach-house to which the chapel is conjoined are all of brick, and it might appear that stone was used to differentiate the little building from the others, for the juxtaposition clearly expresses the Archdeacon's two principal interests, the Church and the turf, with the latter far more evident. The stonework of random rubble is built to courses a foot (about 30 cm) in height, but the horizontal mortar courses are not emphasised. In the lower part of the wall, there are many colourful faces of the stones as found, but the upper part suggests that the builders resorted to quarrying an outcrop, resulting in a preponderance of grey stones. For want of right-angled cornerstones, the quoins and jambs are built of brick.

The infrequency of natural right-angled cornerstones was overcome in a different way in the next important church of dolerite, built at Sidmouth on the west bank of the Tamar for a Scots congregation, beginning in 1835. In the building of what is now known as the *Auld Kirk,* the majority of the stones used at the corners and the openings have been worked to approximate right angles, contrasting the broken surfaces with the naturally weathered faces which in this building are particularly vivid. The stones are not built to courses but are laid so that the longest flat side is the bearing surface, and that imparts a unity to the appearance of a wall in which there are great variations in the size and colour of the stones. The earliest photographs of the kirk show it to have been whitewashed overall.

On the other side of the Tamar, the Launceston builder Robert De Little raised St Mathias' Church for Dr Gaunt in 1842–43, using brick, sandstone and dolerite, but all have been concealed by painting, probably from the time of its completion (Rowland 1966).

It was to be another 25 years before dolerite again appeared prominently in church building, and by then its use was by choice not necessity. Earlier colonial builders using quarried stone were generally delighted to find natural flat surfaces on their stones, but their Victorian successors were concerned to produce a uniform overall appearance in terms of colour and texture and would relegate such fortuities to less honoured positions.

The first Roman Catholic Bishop of Hobart Town, Robert William Willson, was the son of a builder and brother of an architect, both associates of A.W.N. Pugin, and had acted as his own clerk of works in the building of his church in Nottingham before coming to Van Diemen's Land. Like Pugin, he regarded stone as the appropriate building material for a church, and with Henry Hunter as Archdiocesan Architect, they followed the Puginian injunction whenever possible. When churches were commissioned for the north of the colony, economy demanded use of the local stone, and three remarkable buildings of dolerite resulted. All of them have cut sandstone dressings and plastered interiors under timber roofs, but the walls are of dolerite, laid as snecked squared rubble with tuck-pointed joints. This, being interpreted, means that the stones were of varying dimensions, but worked to produce rectangular faces, and laid horizontally but not built to courses, the snecks being smaller stones inserted to continue the line of larger stones for short distances to regularise the appearance of the wall. The mortar at the face was darkened to match the stones, buttered over the

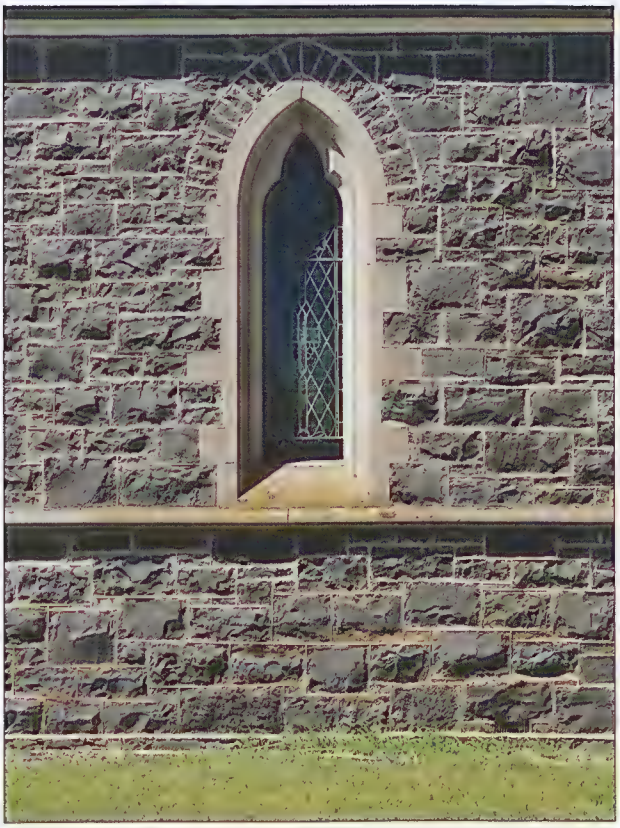

PLATE 8 — St Augustine's Catholic Church, Longford built in 1864: snecked squared dolerite rubble walls, tuck-pointed. Note the Puginian relieving arch above the sandstone of the window.

irregular edges, and grooved to accept narrow false joints of a fine light-coloured composition called lime putty.

The earliest of Hunter's dolerite churches, Saint Augustine's at Longford, was built in 1864, a small building of simple form but designed to be capable of great extension (pl.8). It was a rehearsal for the building of a church in Launceston that would be second only to Hunter's sandstone Cathedral in Hobart Town. A Puginian nave was completed in 1866, the liturgical east end and sacristy were added in 1888 to designs by Alexander North in a different but compatible style, and the tower and spire were built a century later.

The third of Hunter's dolerite churches is Holy Trinity at Westbury, begun in 1867 and completed in 1874 except for the tower, added in 1901 to a design by Alexander North.

In 1868, Archdeacon Reibey commissioned a small dolerite church at Hadspen, but due to a dispute with his bishop, it stood incomplete as a picturesque Gothic ruin until 1951, when it was crudely completed (Henslowe 1977). In the churchyard is a unique monument over the tomb of a local worthy who died in 1870. Like the church, it has smooth sandstone dressings and random dolerite rubble carefully built to miniature courses (pl. 9).

PLATE 9 — The tomb of William Hadfield, a former convict who became the leading citizen of Hadspen and died there in 1870: unique application of dolerite in a small structure.

THE FEDERATION AND EDWARDIAN PHASE

Between 1890 and 1910, the best work in Launceston often included dolerite foundations built with quarried stone laboriously worked to appear as rusticated blocks on the surface, although the hidden sixth side of these was left more irregular. The stones were shaped to a common height of 12 inches, although they varied in length. Foundations of this kind supported brickwork, much of it of bright red machine-moulded bricks from the Sandhill in South Launceston. Domestic basements were often entirely of stone, with the inner surfaces of random rubble built to courses.

The Launceston Municipal Council had inherited the former convict quarry in Cataract Hill near the mouth of the Gorge, and having its own supply, commissioned several new structures. These included some impressive retaining walls around the city, and some unusual buildings associated with the Duck Reach hydro-electric development in the 1890s, including the original powerhouse itself, largely destroyed in the 1929 flood, the suspension bridge pylons, one of which remains, and the staff cottages, mostly intact (pl. 10). A former municipal outlier in the same style is the staff cottage at the inlet to the St Patrick's River water scheme at Nunamara.

In the older parts of Launceston, grey quarried stones appear commonly in boundary walls. In Mid-Victorian examples from about 1850 to the 1880s there are likely to be polite panels below copings and railings and between rendered piers, with buttered mortar and false joints; later ones celebrate the ruggedness of the material with little embellishment, and coping stones of the same material. The structures range in height from dwarf walls supporting railings to retaining walls several metres high.

The most impressive array of regular courses is in the external faces of the apsidal Chancel of St John's Church in Launceston (pl. 11). The work can be precisely dated as there is a photograph taken at the laying of the foundation stone in 1902 that clearly shows the irregular hidden sides

PLATE 10 — Power station worker's cottage, Duck Reach, designed by the City Engineer, C. St. John David and built in 1897.

of the stones and the brick structure that they conceal. The stonework stands on a concrete base hidden below ground level, for the architect, Alexander North (1858–1945), influenced by his associate and sometime partner, A. Harold Masters, was a pioneer in the use of reinforced concrete in non-industrial building.

The stones would have come from the Cataract Hill, probably J. & T. Gunns' quarry in Bourke Street. The work involved in shaping the stones so accurately would have been considerable. There is one stone that must have been nearly finished when too much of an edge broke away, so that large flakes of stone were inserted to maintain the line of the mortar course. The finding of that insignificant fault is an indication of the labour needed to produce the work.

Many houses of similar date have regular courses of quarried stone, but none so extensive as at St John's. They appeared on the 'public' sides of the buildings, with stones of inferior appearance relegated to the back or supplanted by brickwork.

The conveniences of concrete and the increasing cost of labour after the Great War put an end to most of this. One house in Mowbray Heights, probably built around 1920, used dolerite to follow the Californian fashion for porches with posts standing on rugged pylons. A member of the Gunn family, whose firm had built the dolerite towers for the Leading Lights and the attendant lightkeeper's cottages on Port Dalrymple in 1881, built a castellated cottage at Low Head in 1929; *Castle Thurso* designed by Thomas Maloney was about nostalgia with a whiff of Scottish patriotism (Lyons 1998, pp 71–73, Mercer 2017).

St Mary's Church, Hagley, was commissioned by Sir Richard Dry and built in 1862 to an imported design under the supervision of Henry Hunter, with walls of local basalt. The Tasmanian Government built the chancel over the grave of Sir Richard in 1871, but the tower remained incomplete. In 1932, the Launceston architect Hubert Springford East added a vestry and tower of concrete faced with dolerite blocks of troublesome regularity (Scott 1955).

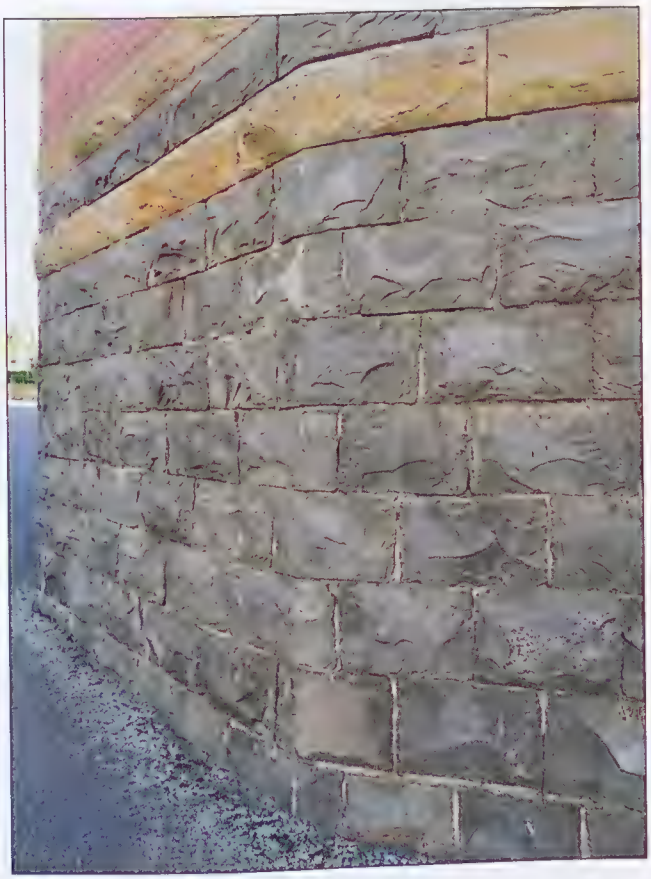

PLATE 11 — Basement of the apse of St John's Church, Launceston, with carefully shaped blocks one foot (30 cm.) high set in lime mortar in 1902.

Public applications were rustic and environmental: the Launceston Municipal Council used slabs from their Cataract Quarry and recycled kerbstones to build shelters at the First Basin in 1937–38 (Green 2006), and an entrance to a park named in honour of Premier A.G. Ogilvie, after his death in office in 1939. The Hobart City Council built handsome chalets beside their new road to the Pinnacle of Mount Wellington in 1938, one of which remains. Beyond these, the use of dolerite was largely confined to rustic paths and walls, until the beginning of the present century.

DOLERITE UNDERFOOT

Before municipal authorities undertook the task, early developers of speculative housing beyond the old town centre in Launceston added to their respectability by kerbing and guttering the roadways in front, and in St John Street there are remnants of this practice that can be accurately dated (Davies 2006). James Bennell's buildings on the east side that Dr Clifford Craig dubbed 'Quality Row' date from 1844, and have cobbled gutters in front, made with large water-worn dolerite pebbles (pl. 12). Later, Dorset Terrace, named for the old Tasmanian county that was a principal source of the tin that made Launceston thrive, was built in 1888, and has a gutter of square setts, continuing earlier work

PLATE 12 — Gutter cobbled with water-worn dolerite stones, and dolerite kerbing, St John Street, Launceston, circa 1844.

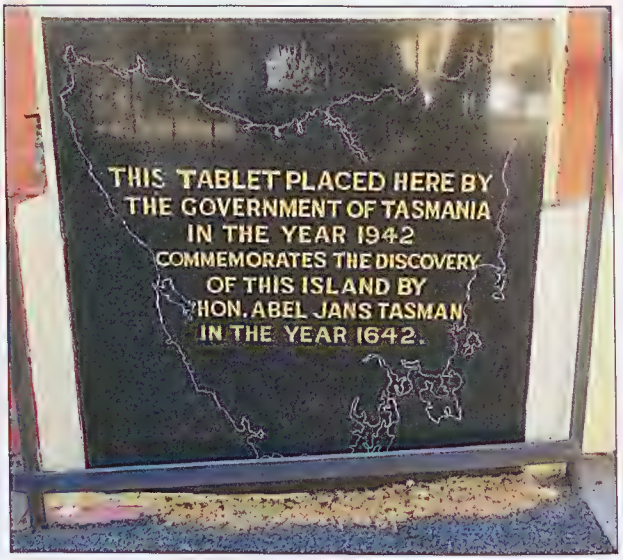
THIS TABLET PLACED HERE BY
THE GOVERNMENT OF TASMANIA
IN THE YEAR 1942
COMMEMORATES THE DISCOVERY
OF THIS ISLAND BY
HON. ABEL JANS TASMAN
IN THE YEAR 1642.

PLATE 13 — 'Black granite' plaque on the Launceston Public Buildings, St John Street.

PLATE 14 — Recycled dolerite as a feature of townhouses in Balfour Street, Launceston, completed in 2018.

using less lustrous vesicular basalt from Victoria. Dolerite kerbing remains a feature in many parts of the city, some carefully shaped, but most of irregular blocks.

Crushed dolerite remains the ultimate road metal, ideal in colour and durability, and an excellent aggregate for concrete, although often supplanted in the latter role by less costly quartzite gravel. It is also excellent railway ballast and filling for gabions.

The Perth Bridge was undoubtedly the greatest engineering structure to be built of dolerite, but there were others, large and small. Excavations in Launceston in the 1980s revealed part of a subterranean storm-water drainage system built of dolerite slabs. The Westwood Road Bridge over the Meander River near Carrick, opened in 1878, has fine dolerite piers and abutments.

With modern powered equipment for sawing and polishing hard stone, dolerite can be used in monumental masonry, where it is promoted and even exported as 'black granite' (pl. 13). It has a suitably funereal appearance, and retains its polish for several lifetimes, if not indefinitely, unlike the more popular grey or pink granite and red syenite.

During the past two decades, dolerite has become once again a fashionable material in northern Tasmania, particularly as a decorative feature and a localising touch added to buildings that are mainly made of industrial materials (pl. 14), and also in the construction of retaining walls built of massive and often colourful subsoil boulders and columns placed with the aid of heavy machinery. Grey quarried stones are used to fill gabions of steel mesh, and this engineering expedient has also begun to appear as a decorative feature.

Finally, within the past year in Launceston, concrete has fought back in the form of dark grey revetment modules coloured and moulded to give the impression of dolerite walls. For 'Tasmania's curse', imitation is the severest form of flattery.

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(accepted 5 December 2020)

Short Note
A BRIEF HISTORY OF THE CENTRAL NORTH FIELD NATURALISTS

by Martha McQueen

(with three plates)

McQueen, M. 2021 (2:vi): Short Note: A brief history of the Central North Field Naturalists. *Papers and Proceedings of the Royal Society of Tasmania* 155(1): 41–42. ISSN: 0080–4703. 35 Adelaide Street, Westbury, Tasmania 7303, Australia. Email: martha.mcqueen@iinet.net.au

This paper provides a brief history of the Central North Field Naturalists since its foundation in 1987 as the Deloraine Field Naturalists and lists the many contributions this community group has made to improving nature conservation and education in Tasmania.
Key Words: Central North Field Naturalists, Tasmania, Disjunct Naturalists, giant freshwater lobster.

HISTORY OF CONTRIBUTION

The Central North Field Naturalists (CNFN aka Disjunct Naturalists, https://www.disjunctnaturalists.com/) was founded in 1987 as the Deloraine Field Naturalists, a community group dedicated to the exploration and preservation of Tasmania's natural environment. Jim and Claudia Nelson and others were instrumental in establishing this group, which now includes over 100 members mainly in northern Tasmania as well as other parts of the state, Australia and overseas. Some of the early projects included work with Dr Pierre Horwitz at the University of Tasmania that led to the nomination of the endemic Giant Freshwater Crayfish *Astacopsis gouldi* (pl. 1) as a threatened species and the protection of its habitat in the Gog Range. Since then, the group has gone on to be involved with frog conservation (including producing an audiotape of frog-calls, now a CD (see the CNFN web page)), platypus research, and education on an endemic group of burrowing crayfish in the *Engaeus* genus that have very restricted ranges in Tasmania. This work has culminated in more information being known about several species especially the Central North Burrowing Crayfish *Engaeus granulatus*, which is now listed as endangered on State and Commonwealth threatened species legislation (https://www.threatenedspecieslink.tas.gov.au/Pages/Central-North-Burrowing-Crayfish.aspx).

The group's ecological knowledge of the Rubicon Estuary contained in *Munginabitta's Country, the flora and fauna of Panatana and Marshalls Hill* by Sarah Lloyd, greatly assisted the Indigenous Land Corporation and Tasmanian Land Conservancy to form a partnership in 2016 and raise the funds needed to protect Panatana for its cultural and natural values (https://tasland.org.au/reserves/panatana/). Another significant contribution of the group has been its acoustic bird monitoring program called 'A Sound Idea' whereby landholders are helped and encouraged to identify bird species on their properties and by doing so contribute data on declining groups such as robins. At the time of its development, this citizen-science approach was new, and became a forerunner to other acoustic monitoring programs now underway in Tasmania.

Over the years, the group has been hosting monthly walks at various locations across northern Tasmania, with occasional weekend ventures. During these activities, members have gained expertise in many areas of natural history, notably identifying fungi, birds, invertebrates,

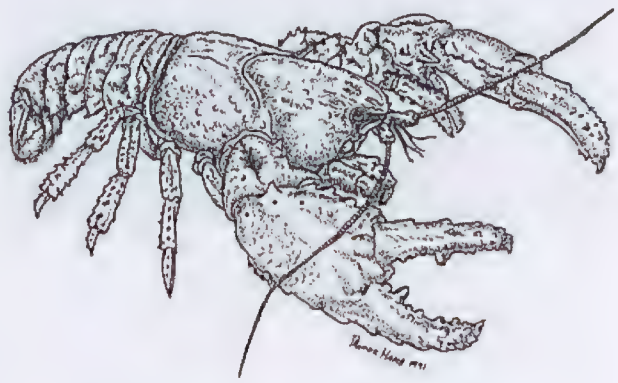

PLATE 1 — Logo on the Central North Field Naturalists website (https://www.disjunctnaturalists.com) featuring the Giant Freshwater Crayfish.

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NORTHERN BRANCH

slime moulds, plants (particularly orchids) and geology. More recently the group has been involved in ecological studies concerning various proposed activities on public land, including the Narawntapu horse trail, the Rocky Cape and Narawntapu running trails, and Kelcey Tier as well as current protection efforts for the Westbury Reserve.

The group's flagship publication, *The Natural News*, is expertly produced three times a year by editor Sarah Lloyd OAM with articles she and others submit (pl. 2). In 2018, in a collaboration with Cradle Coast NRM, two CNFN members, Ian Ferris and Phil Milner, produced the *Beginner's Guide to Common Orchids of North West Tasmania*, containing superb images to help the public identify the many orchid species found throughout the north of the state (pl. 3).

OBJECTIVES

In the nearly thirty years since its formation, the CNFN objectives continue to be:

a. to study and appreciate the natural environment through personal observation
b. to encourage the preservation of the natural environment by bringing together people with similar interests
c. to participate in surveys and research to increase knowledge of Tasmania's biodiversity
d. to provide and disseminate information about the natural environment, and
e. to be a responsible apolitical advocate on environmental conservation matters.

(accepted 6 Nov 2020)

The Natural News
Central North Field Naturalists Inc.
No. 76 – August 2020
PHOENICEA – HAZEL BRITTON
'FEATHERTOP', SUMMER 2019-2020 – PHILIP MILNER
FOOTSTEPS OF MICHAEL SHARLAND AND BRIGADIER HUGH
RN TERRITORY – RICHARD DONAGHEY
Male Flame Robin (Image Barry Baker)

PLATE 2 — Cover of *The Natural News*, No. 76, August 2020. The newsletter is produced three times a year by the Central North Field Naturalists. (Image taken from https://www.disjunctnaturalists.com/naturalnews/76.pdf)

PLATE 3 — A page from the booklet *A Beginner's Guide to Common Orchids of North West Tasmania* produced in 2018 by Central North Field Naturalists members Ian Ferris and Phil Milner. (Image from author)

ECOLOGICAL AND BEHAVIOURAL OBSERVATIONS OF A NESTING AGGREGATION OF THE ENDEMIC TASMANIAN DIGGER WASP *WILLIAMSITA TASMANICA* (SMITH, 1856) (HYMENOPTERA: CRABRONIDAE: CRABRONINAE)

by David Maynard and Simon Fearn

(with one text-figure, six plates and one table)

Maynard, D. & Fearn, S. 2021 (2:vi): Ecological and behavioural observations of a nesting aggregation of the endemic Tasmanian Digger Wasp *Williamsita tasmanica* (Smith, 1856) (Hymenoptera: Crabronidae: Crabroninae). *Papers and Proceedings of the Royal Society of Tasmania* 155(1): xx–xx. ISSN: 0080-4703. Queen Victoria Museum and Art Gallery, PO Box 403, Launceston 7250, Tasmania, Australia (DM* and SF), *Author for correspondence. Email: David.Maynard@launceston.tas.gov.au

The endemic Tasmanian Digger Wasp *Williamsita tasmanica* is only known from 13 registered museum specimens, with little recorded on its life history. A nesting aggregation of females was observed over a 25-day period, enabling the first detailed observations of host log, nest design, prey and egg deposition, and behavioural patterns to be made. Cells were provisioned with large flies (order Diptera) of nine species from nine genera and four families to observe behaviour. This aggregation used a large eucalypt with an exposed core of friable brown rot for nesting. Our study showed that the day-to-day behaviour of the female is predictable, centring on nest construction, hunting large flies and egg-laying. This information has been lodged on the Atlas of Living Australia and voucher specimens collected for the Queen Victoria Museum and Art Gallery to facilitate further taxonomic study.

Key Words: Crabronidae, *Williamsita tasmanica*, Tasmania, endemic, eucalyptus, brown rot, nest design, prey species, egg deposition.

INTRODUCTION

Digger Wasps (Crabronidae) are named after their nesting habit in that, after mating, females dig long tunnels into the soil, sand or in dead wood. A cell, or brood chamber, is located at its end. The cell is then stocked with arthropod prey on which the wasp larva feeds. Many Crabronidae are host-specific, only provisioning brood chambers with particular families, genera or even species; others have 'catholic tastes' (O'Neill 2001), targeting a wide range of species (Evans 1966). Most are solitary and form separate nests; however, some species are gregarious and form nesting aggregations (Marshall 2017, Maximillians 2017).

The world crabronid fauna comprises 9,009 described species (Pulawski 2020a). In Australia there are 689 described species; the majority (442 species in 29 genera) are in the subfamily Crabroninae (AFD 2020a, b). Currently just 12 described species in three genera within the tribe Crabronini are recorded from Tasmania (ALA 2020a, Pulawski 2020b) (unrecorded species may be present). These include three species of the little-known genus *Williamsita*: *W. bivittata* (Turner 1908), *W. neglecta* (Smith 1868) and the endemic *W. tasmanica* (Smith 1856) (Semmens *et al.* 1992, AFD 2020d). In late March 2020 the first author discovered a number of *W. tasmanica* that were using sections of a rotting log as a nesting site. Here we report our ecological and behavioural observations of this nesting aggregation of *W. tasmanica*.

About *Williamsita*

The 11 known species in the genus *Williamsita* Pate, 1947 comprise nine that are endemic to the continent of Australia, one to New Caledonia and one to Vanuatu (Leclercq 2006). *Williamsita* are recorded in all Australian states and territories with some species widespread, and others endemic to specific states or regions. Little is known of *Williamsita* natural history. To the best of our knowledge, only *W. bivittata* has been reported on; with host log, nesting behaviour and design, feeding behaviour and diet being documented by McCorquodale *et al.* (1989) and Evans and Matthews (1971).

Williamsita in Tasmania

Williamsita tasmanica has previously been collected in small numbers from Cranbrook, Poatina, Liffey, Scottsdale, Wayatinah, Falmouth, Harford and Arthurs Lake. During the review of this manuscript a further 15 specimens were identified at the Tasmanian Museum and Art Gallery. *W. neglecta* is known from South Australia and Tasmania; in Tasmania it has been collected from Scottsdale in 1949 (a single specimen, interestingly collected alongside four *W. tasmanica*), Pioneer, Cranbrook and Herrick. *W. bivittata* is recorded from New South Wales, Queensland, South Australia, Victoria and Tasmania. However, in Tasmania it is apparently only known from two specimens: a male collected in Launceston in 1915 and a female from Ellendale in 1949 (fig. 1) (Leclercq 1974, 2006; AFD 2020c, ALA 2020b).

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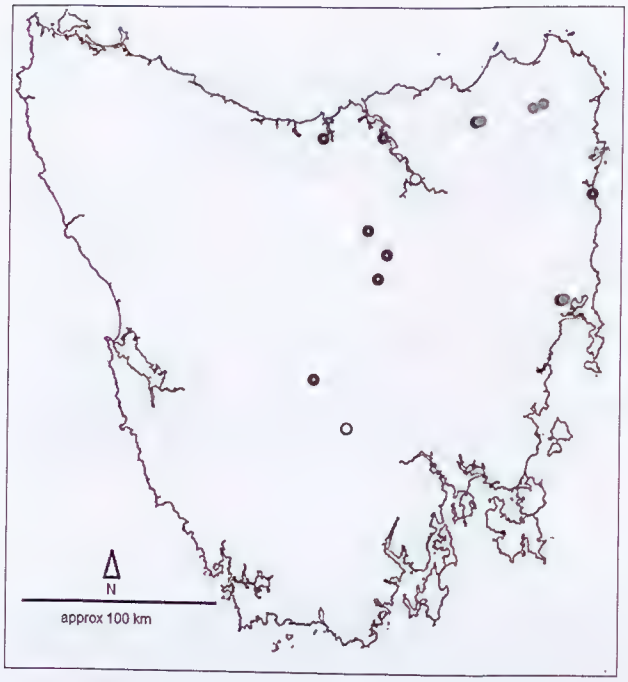

FIG. 1 – Known Tasmanian collection locations for *Williamsita tasmanica* (black), *W. neglecta* (grey) and *W. bivittata* (white). Data from Leclercq (2006) and this study.

Williamsita tasmanica

While there are numerous subtle morphological differences among the three *Williamsita* species found in Tasmania, the most obvious is the colour of the banding on the thorax and abdomen – *W. tasmanica* has yellow (pl. 1), whereas *W. bivittata* and *W. neglecta* have orange.

FIELD OBSERVATIONS

The wasps were found on a peri-urban property at Deviot in the Tamar Valley, northern Tasmania (493878 E 5435390 N, 60 m altitude) in an open-pasture habitat with extensive eucalypt woodland about 70 m away. The female wasps were observed opportunistically over 15 days between 28 March and 21 April 2020 and direct observation and video review were used to gather behavioural data. They were first observed visiting the cross-sections of a recently cut, well-aged eucalypt log measuring 600 mm diameter. The heartwood was extensively affected by brown rot. Five discards of the rotten heartwood (referred to here as cores), each measuring 200–400 mm diameter and 300 mm long, formed the basis of our observations (pl. 2).

During the observation period, the mean maximum and minimum temperatures were 18.5°C and 8.8°C, respectively (BOM station 091237). This mean maximum temperature was down nearly 6°C on the summer maximum temperature when insect optimal performance and hours of activity would be maximised (see O'Neill 2001, Chapter 9 and Bale *et al.* 2002 for an overview of thermoregulation), and the wind-chill factor on some days caused the apparent air temperature to be as much as 12°C

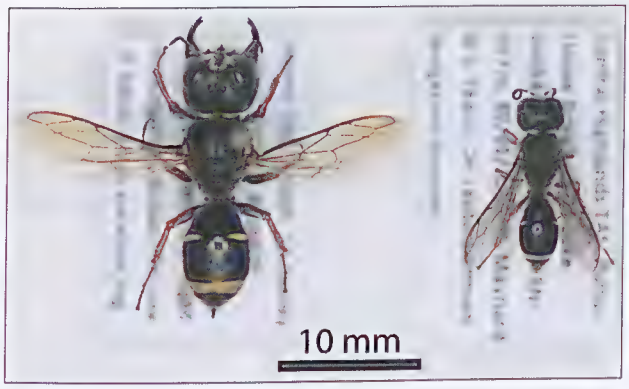

PLATE 1 – *Williamsita tasmanica*. Female (left) (QVM.2020.12.0013), and male (right) with lateral abdominal banding inset (QVM.2020.12.0006).

below the actual temperature. An infrared thermometer was used to measure surface temperatures at the nest entrance. Rainfall was sporadic during this time; six of the 25 days had precipitation greater than 1 mm, and the most rain in a 24-hour period was 35.8 mm (BOM station number 091255). Wasps were not observed active outside the nest on cold and/or high rainfall days.

Observation methods

Direct observation provided some limited information on the wasps' hunting behaviour when they were away from the nest, while over 20 hours of continuous video was recorded on 1) a wide angle GoPro video recorder, and 2) a Nikon D800 DSLR with a 60 mm prime lens. This footage was reviewed and the time spent at different locations within the nest, or undertaking various activities including behaviour was recorded. Seven positions, and associated behaviour, were identified:

- in nest (out of sight: probably digging, storing prey, depositing egg or akinesis ('asleep'))
- inside entrance (sitting stationary, grooming or digging)
- at entrance (removing frass, grooming or apparently basking)

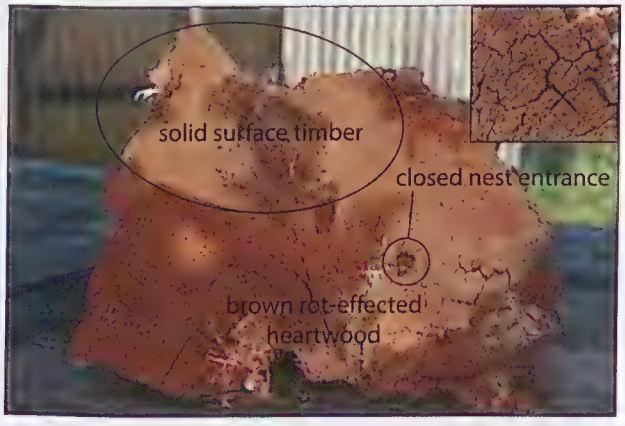

PLATE 2 – One of the five cores used by *Williamsita tasmanica*, and the cuboidal effect created by the brown rot (inset).

- head out of entrance (apparently basking)
- thorax out of entrance (apparently basking, or preparing to take flight)
- in flight (orientation flight), and
- out of view (flown away and probably hunting or feeding).

It is difficult to determine how many different individuals were observed over the observation period; however, two long-term residents provided the bulk of the video footage. Another two wasps appeared to reside for many days, but may have moved between the nests being observed, and it is unclear how many non-resident wasps were short-term visitors. The generalised behaviour pattern described below is drawn from observing many wasps for a short time, and a few wasps for a long time. This reflects the opportunistic nature of the study.

By 21 April there were no active wasps and the nests were opened. In all, 11 nests were opened and at least 25 prey items were recovered. Only one resident female wasp remained; she was captured, along with nine that had been netted in flight at the start of the observation period. These specimens were lodged in the entomology collections of the Queen Victoria Museum and Art Gallery (QVMAG) (QVM.2020.12.0007-0016; pl. 3). Nest design was recorded and the prey preserved and also lodged in the QVMAG collection (QVM.2020.12.0017-0039). The wasps average head width was 4.57 mm ± 0.5 (SD) (range = 3.8–5.2 mm), and body length was 16.33 ± 1.1 (SD) (range = 14.3–18.1 mm, n=10).

OBSERVATIONS ON BEHAVIOUR

Nesting behaviour

Site selection

Female wasps were immediately attracted to newly exposed brown rot cores. They flew slowly and closely to the vertical surfaces of the wood investigating all potential nest sites whether they were in solid or rotting wood. It was clear that some sites presented certain attributes apparent only to the wasps, initially attracting them, even though they were not always suitable nest sites. A few nests that were started in semi-solid timber were eventually abandoned whereas all successful nests were established in brown rot cores.

At each potential site (e.g., beetle larval gallery; crack or indentation in the brown rot), a wasp would land and immediately investigate. They would examine the potential entrance, or enter and inspect more significant voids or galleries, and then quickly take flight and move on. Often a wasp would return to previously explored sites. Also, these same sites were inspected by other visiting wasps.

Some sites were abandoned after a short period of 'appetitive digging' (Evans 1966). For instance, one former larval gallery of a longhorn beetle (Coleoptera: Cerambycidae), which formed a 'u'-bend with both ends opening close together on the same surface, was initially attractive to the wasp. After a short time digging, it quickly abandoned this gallery. Many wasps visited this and similar sites, and repeated the process – inspect, dig, abandon.

Digging

Initiating galleries in undisturbed brown rot cores: One wasp was observed beginning a nest in a split between cubic sections in the brown rot (pl. 4). The wasp vigorously chewed away the brown rot, rotating its head back and forth about 320°, and its body 360° as it bored head-first into the wood. The front pairs of legs intermittently raked frass beneath the body, with the rear legs then pushing it backwards and outwards. Raking was aided by the presence of pecten (comb-like structures) on the tibiae and tarsi of the intermediate and posterior legs. The resulting mound of frass surrounded the entrance and the wasp made no attempt to move it further. At some stage the nest became deep enough, and wide enough for the wasp to enter and turn around. The wasp then began to push the frass out of the entrance with its head and mandibles like a bulldozer. The bulldozer method was the *modus operandi* for nest excavation by all the other wasps observed.

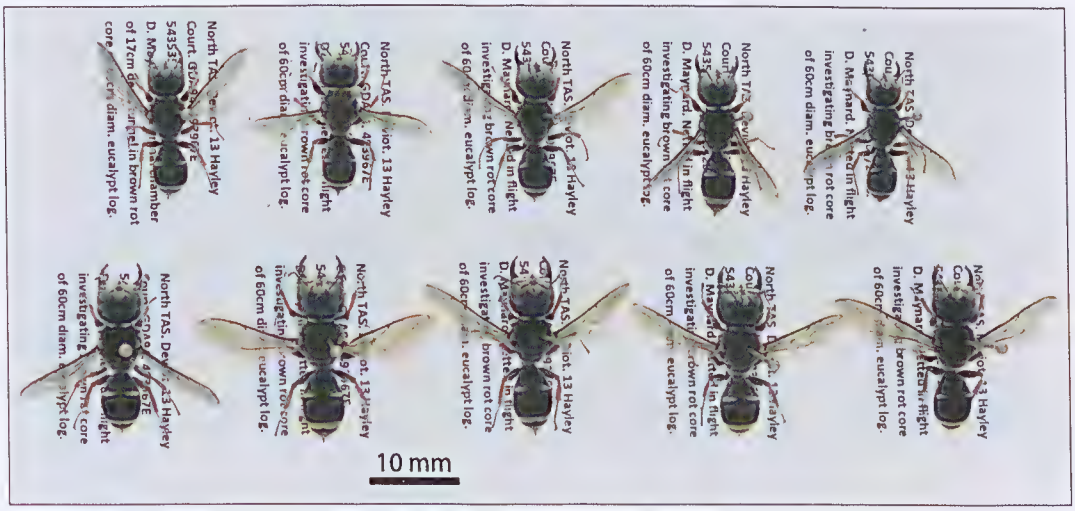

PLATE 3 – Female *Williamsita tasmanica* collected in this study (QVM.2020.12.0007-0016).

PLATE 4 – Female *Williamsita tasmanica* initiating a gallery in the brown rot core of a eucalypt log. Note the mound of frass around the entrance.

Utilising an existing hole

Most nests were made using existing holes or significant (> 10 mm deep) depressions and splits in the cores. These openings measured 6–10 mm diameter/width. Once a hole was deemed suitable the wasp would begin to excavate deep into the brown rot.

Burrowing

In the early stages of nest-making wasps would repeatedly disappear into the nest, before returning to the entrance pushing out frass, followed by basking or grooming in the entrance. During a one-hour period, wasps were observed moving between the nest interior and entrance between eight and 20 times. They would spend between 10 seconds and eight minutes inside the nest, and 15 seconds to five minutes sitting in the entrance after pushing out the frass. This same pattern of behaviour was repeated in well-established nests during the morning hours when the temperature was 14°C–17°C degrees.

Unsuccessful nests

Of the 11 nests observed, five were 'unsuccessful', in that they were abandoned after one or two days of digging. Visiting wasps would inspect these nests but also abandon them. When the nests were opened it was apparent that the brown rot was minimal and hard wood was encountered during digging, limiting nest expansion. Typically, these nests were single, horizontal galleries measuring 30–60 mm in length and 12–14 mm in diameter. The end of the gallery was slightly bulbous, indicating exploratory digging to continue into the core.

Successful nests

The remaining six nests were successful in that they were inhabited for multiple days, and when opened, contained one or more cells (discussed further). These nests were monitored to document the daily routine of *W. tasmanica*.

Daily pattern of behaviour

The resident wasps used these nests for up to 21 days. Each day they repeated a limited range of activities.

Opening the nest

A visible plug of frass closed off most nests from mid-afternoon to early morning each day. This plug was removed when the temperature reached 14°C. The wasps would then sit inside the entrance for about one minute, and then expose their head, and eventually their thorax, to the sunlight for around five minutes. They then retreated into the nest interior to dig.

A cycle of digging for 1–4 minutes, followed by pushing frass out of the nest, continued until the temperature reached 16°C. Frass was pushed out of the entrance using the head and mandibles. Digging lasted for 90 minutes or more. Sometimes the wasps would break from digging to either sit inside the entrance grooming themselves for 2–15 minutes or exposing their head and thorax to the sun for 1–2 minutes.

Once the temperature reached 16°C the wasps became more active, first by repeatedly moving between the entrance and the nest interior, and then spending more time at the entrance. They would sit at the entrance, eventually exposing their head and thorax to the sun for a few minutes at a time before again returning into the nest. This continued until it reached 17°C which was the temperature at which flight began.

Immediately prior to taking off, the wasps would typically pause for about 10–30 seconds, first inside the nest, then at its entrance, then with head protruding from the entrance and finally with the thorax also protruding. This was repeated on nearly every flight by every wasp. After taking off the wasps conducted an orientation flight.

Orientation flights

When the wasps left the nest they first conducted an orientation flight to collect visual clues for their return flight. They would take 10–30 seconds to survey the nest site and immediate surrounds before leaving the area. On days with multiple flights of shorter duration the orientation flight was reduced to 2–5 seconds in the latter flights.

Hunting

Two adults were observed apparently searching logs for prey. They used an attenuating, creeping-line search pattern, repeatedly flying past small, dark-coloured, cuts and abrasions on the logs, sometimes landing and then immediately taking off. It was apparent that any small, dark-coloured irregularity on the logs may have resembled a basking fly to the wasp (as flies were the only prey items found in cells).

It is unknown where the wasps went to successfully hunt. The time away from the nest varied between 8 and 103 minutes, and the maximum number of flights recorded by one wasp in one day was six. Wasps were recorded returning to the nest, some a single, presumably paralysed prey which was carried below the body with the head facing forward. One wasp was recorded making four consecutive successful

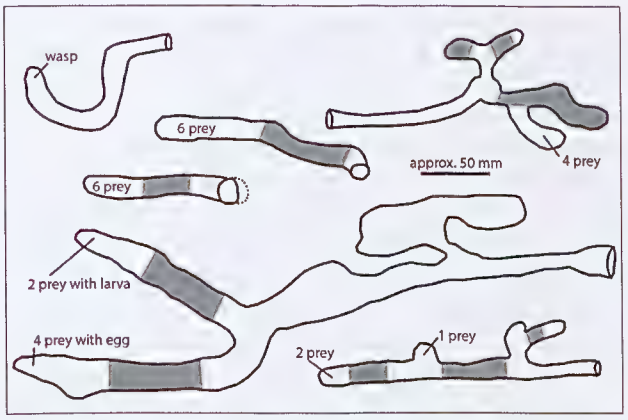

PLATE 5 – Two-dimensional diagrammatic representations of six nests of *Williamsita tasmanica* (not to scale). Shading represents frass plugs.

hunts within 162 minutes. Each return to the nest was 1–3.5 minutes long, which was presumably enough time to lodge the prey in a brood cell and possibly to lay an egg (discussed below).

Defending the nest

Wasps vigorously defended their nests from conspecific females as well as other hymenopterans. Resident wasps were seen blocking the entrance to stop conspecifics landing. In one instance the native bee *Callomelitta picta* (Colletidae), which also nests in soft rotting wood and were seen to regularly search the cores in the mid-afternoon, was seen to enter a *W. tasmanica* nest and leave after being forcefully ejected. If two *W. tasmanica* were in flight near a nest the resident wasp would repeatedly attack the competitor from behind until it moved away from the entrance. Non-resident wasps were not seen to successfully enter a nest when the resident was present. However, we were not able to identify individual wasps and so cannot be sure if non-resident wasps entered unattended nests.

Inspecting the nests

Nest design

The simplest of the opened-up nests were single, horizontal tunnels, measuring 90–140 mm long and 10–12 mm in diameter, and terminating in a cell. Tunnels ran parallel to the long axis of the log, with the grain of the timber, and following veins of brown rot. The more complex nests were 130–175 mm long, with a long main tunnel and one or more side branches, or shallow caverns, each ending in a cell (pl. 5). In all cases, cell length was 10–20 mm, and each cell was sealed closed with dense plugs of frass 20–60 mm in length.

Prey

Five of the successful nests contained some cells with between one and six presumably paralysed prey, all inserted head-first. The prey comprised adults of 11 species from four fly families (table 1; QVM.2020.12.0017-0039). The average prey body length was 10.46 ± 1.44 mm (SD) (range 8.25–12.75 mm).

Egg deposition

Evidence of egg-laying was found in two chambers within the one nest. First, an egg was found fastened to the 'throat' of a fly, i.e., ventrally between the head and prothorax (pl. 6, left). On the second occasion, a first instar larva was found at this same body position, apparently feeding through the cervical membrane (pl. 6, right).

There was also what appeared to be a larval cocoon in a chamber with older (desiccated and crumbling) host flies. This casing may be of a *W. tasmanica* that had successfully completed development and hatched earlier in the season or the previous one.

PLATE 6 – *Williamsita tasmanica* egg (left) and first instar larva (right) on *Calliphora stygia* (Calliphoridae) prey.

TABLE 1 – Prey species collected from five nests of *Williamsita tasmanica*, April 2020

Family	Species
Calliphoridae	
	Chrysomya rufifacies (Macquart, 1843)
	Calliphora (Paracalliphora) hilli (Patton, 1925)
	Calliphora (Neocalliphora) stygia (Fabricius, 1782)
Syrphidae	
	Austalis cf. *copiosa* (Walker, 1852)
	Melangyna sp. Verrall, 1901
Tachinidae	
	Microtropesa sinuate (Donovan, 1805)
	Tritaxys sp.
	cf. *Parerigonini* (undescribed species)
	Eurygastropsis cf. *tasmaniae* (Walker, 1858)
	Prodiaphania sp.
Tabanidae	
	Scaptia (Scaptia) patula (Walker, 1848)

DISCUSSION

Here we report the first observations of host log, nest design, prey and egg deposition, and behavioural patterns of *W. tasmanica*. There are similarities with *W. bivittata*, the only other species of *Williamsita* to have been studied. McCorquodale *et al.* (1989) provides comprehensive information on nest design, prey diversity and egg deposition from an aggregation collected from a eucalypt log in Canberra. There are similarities in the density of that eucalypt log and the cores in this study, in that they reported variable moisture content and firmness through the log, typical of decaying timber. Evans and Matthews (1971) made a brief reference to females and their calliphorid prey that were collected from a willow log in suburban Melbourne, which indicates that *W. bivittata* is capable of using host logs from multiple tree species; however, no mention was made of its density or the presence of decay.

Methodology and study site

The detailed information gained in this study by reviewing and replaying video footage far exceeded that of direct observation. However, this only applied to activity in front of the camera; direct observation provided supplementary information outside the camera's field of view. The presence of an observer did not appear to influence wasp behaviour except when a shadow crossed their path, in which case they retreated into their nest or, if they were in flight, moved a short distance away for a short time. Video negated this risk and allowed for longer and more detailed study than would have been possible by direct observation.

The location of the brown rot cores in this study, being in the middle of a paddock and exposed to the elements, is not entirely natural. There is a possibility that this situation could be naturally replicated on a grazing property. However, it is more likely that brown rot would be exposed in a woodland or forest setting. The microclimate, amongst many factors, in these two settings is highly likely to be very different, and hence the suitability for *W. tasmanica* use.

Host log

The importance of large-diameter dead eucalypts with brown-rot centres (standing and fallen) in temperate forests to saproxylic insect diversity, particularly beetle diversity, is well established (Grove 2002, Grove & Meggs 2003, Yee 2005, Yee *et al.* 2006, Wardlaw *et al.* 2009, Grove & Forster 2011). *W. tasmanica* can now be added to the list of Tasmanian invertebrates utilising this same habitat. Our study log, when first cut to expose the cross-sections with rotten heartwood, mimicked a recently fallen dead eucalypt. This rotten heartwood appeared to make for easy digging, yet maintained its structural integrity, and would provide relatively stable moisture levels and temperatures, as well as protecting cells during larval development (see Yee 2005).

Nest design

Nests of *W. tasmanica* and those of *W. bivittata* are very similar, both having generally horizontally orientated tunnels and with side branches, where present, terminating in a cell closed off with frass. Where the species' nests differ is in the number of sequential cells in any branch. Documented nests of *W. bivittata* have multiple branches, each with up to three sequential cells, whereas all our observed *W. tasmanica* branches are single-celled, except for one containing two cells. This may simply reflect the characteristics of the host log (ease of digging) and/or the time available to the wasps for nest-building prior to being opened. These factors may also explain the prevalence of short branches and the presence of shallow cavities in the *W. tasmanica* nests. Another difference is the tunnel diameter: those of *W. tasmanica* (10–12 mm) are about 50% larger than those of *W. bivittata* (6–8 mm; McCorquodale *et al.* 1989). This reflects the size difference between these two species, the head of *W. tasmanica* in this study (4.57 mm) being 70% wider on average than that of *W. bivittata* (2.68 mm). This difference in size influences the prey size targeted by each species (discussed further).

Many Crabroninae utilise natural cavities or borings made by beetles and other insects (Evans 1966, O'Neill 2001); usurpation and supersedure are also common. These behaviours reduce energy costs of nest construction and foraging (O'Neill 2001, p.179, 181). *W. tasmanica* was no different; many females showed interest in the nests of conspecifics, in splits and cavities in brown rot, and in longhorn-beetle galleries. It is well established that in Tasmania small and large eucalypts support different saproxylic beetle assemblages (Yee *et al.* 2006), and that successional patterns within this group exist (Wardlaw *et al.* 2009). *W. tasmanica* is just one of many invertebrates that benefits from the actions of saproxylic fungi and beetles in old, large-diameter eucalypts with brown rot.

Diet and prey

Adult wasps were not observed feeding; however, crabronids in general are known to be nectar-feeders (O'Neill 2001, p. 115; Evans 1966, p. 124). In 2016, a female *W. tasmanica*

was collected from *Leptospermum* blossom very near to this study-site (QVM.2020.12.0005); and in 2020 a male was collected from *Leptospermum lanigerum* blossom near Arthurs Lake in the central highlands (QVM.2020.12.0006). All other adult *Williamsita* specimens in the QVMAG collections were collected from the blossoms of *Kunzea*, *Leptospermum* or *Baeckea*. It may be that *Williamsita*, like some other crabronids, also feed by malaxation (feeding on exudates of chewed, immobilised prey), or feed directly upon prey (Evans 1966, O'Neill 2001), which make these items unsuitable for stocking larval cells.

No prey items were seen being captured; however, adult female *W. neglectus* have previously been observed catching calliphorid flies that were nectaring on *Baeckea virgata* blossom. The wasps flew rapidly alongside and over the shrubs, searching for nectaring flies. When a fly was detected, the wasp immediately darted in at high speed to catch and presumably paralyse it (S. Fearn, pers. obs.). On one occasion a wasp with its prey was captured directly from the blossom (QVM.2020.12.0069)

Prey comparison

On the basis of the observations reported here and in the literature, there appears to be no overlap in the prey taken by *W. tasmanica* and *W. bivittata*; however, as is typical for Crabronini, both species target adult flies from a variety of families (O'Neill 2001). Evans and Matthews (1971) reported one prey species, *Onesia tibialis* (Macquart, 1846), for *W. bivittata* in Melbourne; while McCorquodale *et al.* (1989) report a broader prey list for *W. bivittata* in Canberra, comprising adults flies of four families: Calliphoridae (*O. tibialis*, *Calliphora dispar* Macquart, 1846, *Calliphora* sp.); Rhiniidae (*Stomorhina discolor* (Fabricius, 1794) and *S. subapicalis* (Macquart, 1847); Stratiomyidae (*Odontomyia* sp.); and Therevidae (*Agapophytus* sp.). Each of these species' measures about 6 mm in length. The prey of *W. tasmanica* included Calliphoridae but also species of three other families (Syrphidae, Tachinidae and Tabanidae) not previously reported from *Williamsita* cells. These lists of prey are unlikely to be exhaustive since they characterise cell composition at specific individual locations) and times.

The small number of wasps and prey recorded in this study precludes any rigorous analysis of prey size preference. However, since there is so little information on *Williamsita* generally, it is worth some investigation. The ratio of average prey body-length (10.46 mm, n=18) to female wasp body-length (16.33 mm, n=10) for *W. tasmanica* is 0.64:1. This means the females caught and carried prey about 64% of their length.

The ratio of average body length to head width (4.57 mm) for female *W. tasmanica* is 3.66:1. If this ratio is applied to female *W. bivittata* (average head width 2.68 mm; McCorquodale *et al.* 1989), then the average body length can be estimated at 9.58 mm. This means that for *W. bivittata* the ratio of average prey body-length (about 6 mm) to wasp body-length is 0.63:1, meaning that they catch and carry prey about 63% of their body length – an almost identical ratio to that of *W. tasmanica*. This may reflect a partitioning of resources according to prey size where *W. bivittata* and *W. tasmanica* are sympatric in Tasmania. *W. tasmanica* targets prey that is about 40% larger than that targeted by *W. bivittata*.

Egg deposition comparison

The number of prey (one to six) and eggs laid in each cell (one), and the positioning of the egg on the 'throat', are consistent with *W. bivittata* (McCorquodale *et al.* 1989), and Crabronini generally (Evans 1966, O'Neill 2001). However, only two cells were found, each with a single, live egg/larva, both from one nest (pls 4, 5). The larva was provisioned with four calliphorid flies while the egg only had two tachinids. A cocoon of a distinctly hymenopteran (i.e., wasp, bee or ant) type, and possibly that of *W. tasmanica*, was in a cell with four tachinids and a (smaller) syrphid. These are not enough data to understand the minimum prey requirements for a *W. tasmanica* larva to complete development. The smaller *W. bivittata* packed cells with 4–11 smaller-sized flies (McCorquodale *et al.* 1989). Prey number per cell is influenced by cell dimensions, and the relative availability of suitably sized prey (O'Neill 2001). The number and size of provisioned prey determines the eventual size of the adult wasp but may also be linked to its gender (O'Neill 2001); female-biased sexual size dimorphism in solitary wasps is common (O'Neill 1985, 2001, MacKauer 1996).

Predators and parasites

Predators of *W. tasmanica* were not observed. However, the ant *Rhytidoponera victoriae* was seen on a number of occasions approaching (and once entering) the nest, with *W. tasmanica* hastily retreating into the nest. It is unlikely that a solitary ant measuring 5 mm in length would be a threat to a wasp three times its size; however, McCorquodale *et al.* (1989) reported a female of the smaller *W. bivittata*, minus wings, being dragged from a nest by ants (*Iridomyrmex* sp.). Other ant species, particularly those that nest in rotten wood (e.g., *Camponotus hartogi* and *Polyrhachis* spp.) may pose a threat to *W. tasmanica* eggs/larvae and their stored prey items. These wasps also experience parasitism: McCorquodale *et al.* (1989) reported fly larvae (Muscidae and possibly Chloropidae) in the cells of *W. bivitatta*.

Overwintering

Most wasps in temperate regions overwinter as pre-pupae within the nest cells (O'Neill 2001). This would appear to be the case for *Williamsita*, which can produce multiple generations in one season. The cells of *W. bivittata*, examined in mid-summer, contained varying numbers of eggs, larvae of three sizes, and empty larval cocoons; each of these stages was associated with prey that had been consumed to a corresponding degree (McCorquodale *et al.* 1989). Our nests of *W. tasmanica*, when examined in early autumn, contained an egg and a first-instar larva, and it's unlikely the larvae would have been able to reach adulthood before winter. A review of the collection dates for adult temperate Australian *Williamsita* specimens examined by Leclercq (2006) (n=38) indicates adult wasp activity between October and April. Peak activity appears to be in December, January and March. This preliminary analysis is subject to selection

bias; however, it implies that the first adults emerge in mid-spring, which in turn supports the notion of overwintering larval stages. It is unknown whether some *Williamsita* may overwinter as adults.

CONCLUSION

Williamsita tasmanica is a large, endemic digger wasp that has been observed nesting in a brown rot-affected, large-diameter eucalypt log. Our study demonstrates that the day-to-day behaviour of the female is predictable, centring on nest construction, hunting large flies and egg-laying. While we were not able to gather any information on male behaviour, this study reinforces the ecological value of course woody debris derived from large-diameter mature trees.

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CHANNEL TO THE STRAIT: THE GEOLOGICAL HISTORY OF THE TAMAR VALLEY–LAUNCESTON AREA

by Keith Corbett

(with six text-figures)

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The Tamar Valley occupies the Tamar Graben, a geological structure defined by a series of parallel NW-trending faults which have lowered the dolerite basement to below sea level. The resulting narrow trough, some 50 km long and 5 km wide, has been partially infilled with soft sands, clays and gravels, with intercalated basalt flows in places, of mainly Paleogene (lower Tertiary) age. Low hills of hard Jurassic dolerite define the structure on either side. The graben was formed during the break-up of Gondwana, the separation of Australia from Antarctica, and the making of Tasmania, in the Cretaceous-early Cenozoic period, some 70–140 million years ago (Ma). A spreading ridge had propagated eastwards through the Great Australian Bight but was unable to break through the Bass Strait area, and instead a large wedge of crust containing the future Tasmania was pulled away from the corner of Antarctica on a series of transcurrent faults. The associated crustal stretching in the Bass Strait area resulted in the formation of the deep 'hole' of Bass Basin, which had offshoots onto what became Tasmania, including the Tamar Graben. For much of its life, the Tamar River was a major feeder stream into the Bass Basin, carrying large volumes of sediment eroded from the Tasmanian highlands. The course of its major tributary, the South Esk River, within the southern part of the graben was completely blocked by basalt flows near the present Evandale about 35 Ma, forcing it into a new course to the west through the dolerite, to form the Cataract Gorge.

Key Words: Tasmanian geology, Tamar Valley, Tamar Graben, Launceston geology, Bass Basin, Gondwana.

INTRODUCTION

The Tamar Valley, in central northern Tasmania, is a linear NW-trending lowland, averaging 5 km in width, and extending inland from the coast for about 50 km. The valley is mostly underlain by soft Cenozoic sediments, with some intercalated basalts, but is confined on either side by low hills of hard Jurassic dolerite. The tidal Tamar River, typically 1–2 km wide, flows through the valley, with wide mudflats and wetlands in places. The river follows a meandering course, producing a series of rounded 'peninsulas' of the Cenozoic rocks along the sides of the valleys, most of which contain small villages and farms. This pattern is broken on the western side near the mouth, where two finger-like bays, called West Arm and Middle Arm, project outside the dolerite confining arm (which is here submerged) for several kilometres, near the townships of Beauty Point and Beaconsfield.

The city of Launceston lies at the head of the valley, where the two main rivers which feed the Tamar, the North Esk and South Esk, flow into the lowland. The North Esk enters the lowland several kilometres south of Launceston at the Corra Lynn dolerite gorge, then flows through a wetland area for some 10 km before entering the Tamar from the north side. It drains a tract of hilly to mountainous country to the east. The South Esk enters from the western side via a larger gorge (Cataract Gorge) cut through the dolerite hills. It has a number of major tributaries (Meander, Liffey, Macquarie, Elizabeth, Nile), and drains a large area extending from Ben Lomond in the east, across the Fingal Valley and northern Midlands valley to the northern part of the Central Plateau. The overall Tamar drainage area is the largest of any of the state's rivers. The South Esk is dammed for hydro-electric power in the hills just above the gorge, with a power station at Trevallyn, on the NW side of Launceston, replacing an earlier station within the gorge destroyed by a flood in 1929.

The tidal nature of the Tamar reduces the flushing power of the rivers, so that silting is an ongoing problem. Dredging of the riverbed has been undertaken near Launceston multiple times. There are extensive mudflats and shoals in some areas and introduced 'Rice Grass' (*Spartina anglica*) has taken over large areas. The lower part of the river remains navigable for large ships, however, and the deep-water port of Bell Bay, some 12 km in from the coast, services the largest industrial complex in Tasmania, including an aluminum smelter and ferromanganese plant. Good highways traverse both sides of the valley, with several bridges at Launceston and the Batman Bridge at Deviot, about 20 km from the coast.

The first European settlement of the Tamar area was as an outpost from Sydney in 1805, the initial settlement at York Town, on West Arm, being moved to Launceston a year later.

A GONDWANAN BEGINNING

The formation of the Tamar Valley relates back to the very making of Tasmania, when the supercontinent Gondwana was breaking up through the Cretaceous Period, 140–65 million years ago (Ma). This story is related in more detail elsewhere (Corbett 2019), but in summary, continents are pushed together and then dragged apart according to great slow-moving convection currents in the Earth's mantle beneath the continents. These convection currents are driven by 'hot spots' or hotter areas in the Earth's molten core, and the location of these hotspots changes over long periods of time. If a new hot spot forms under a continent, or supercontinent, then that supercontinent will be slowly pulled apart, and a new arrangement of continents and crustal fragments will eventually result. Gondwana came together about 550 Ma, and was basically stable for a very long period, until something changed in the core and it began to be pulled apart about 150 Ma. All of Tasmania's well-known Palaeozoic and Mesozoic geological formations, including the Cambrian Mt Read Volcanics, the hard siliceous conglomerates of places like the West Coast Range and Mt Roland (late Cambrian), the great Ordovician limestone sequence which contains most of the caves around the state (and is mined at Flowery Gully), the widespread granites of the NE and eastern Tasmania, the Permian mudstones with their marine fossils, and the Triassic sandstones with their coal seams in places, were deposited or emplaced during this long interval when Tasmania and Australia were connected to Antarctica along the eastern side of Gondwana.

The beginning of the change in Gondwana came in the Jurassic, about 180 Ma, and was marked by the intrusion into the crust of thousands of cubic kilometres of molten dolerite derived from the upper part of the mantle. The dolerite came up through cracks in the old folded rocks, then spread laterally through the horizontally layered Permian and Triassic beds. The zone of intrusion extended from southern Africa across the full width of Antarctica to the position of Tasmania, which at that stage was located at the corner of Antarctica. Mainland Australia, as it was then, was slightly further away to the NE, and the massive intrusions of dolerite did not extend this far. In most areas, some of the dolerite reached the surface, and was erupted as basalt flows (e.g., in the Drakensberg Mountains of South Africa) but most of the dolerite in Tasmania is in the form of flat sheet-like intrusions called sills, 100–800 m thick, injected into the Permian and/or Triassic sediments. There are very small flows of Jurassic basalt on Kangaroo Island and in Victoria, at Coleraine. But the great dolerite sills, and the mountains and cliffs and landscapes they produce, dominated by the 'organ-pipe' cooling columns (formed as the hot sills cooled and contracted slightly) and the great swathes of heavy dolerite scree on the slopes below the cliffs, are a feature of Tasmanian geology not seen on the mainland. Nearly half of Tasmania is, or was, occupied by dolerite, and we may well be considered the dolerite capital of the world.

Gondwana continued to stretch and rift after the dolerite was emplaced, and the first chunks to separate from Antarctica (which acted rather like an anchor), at about 125 Ma (early Cretaceous), were Africa and India. India pulled away sideways from Australia at about the same time. The separations occur along spreading ridges, where basalt from the upper mantle is injected into the very attenuated crust and eventually forms new ocean crust. New oceans are formed in this way. India seemed to be caught on a particularly fast current in the mantle, and 'sped' northwards at about 20 cm per year (the normal spreading rate is 5–8 cm per year — slightly faster than fingernails grow), eventually colliding with Asia at around 55 Ma to begin the process of pushing up the Himalayas. Africa and South America began separating at about 100 Ma, and the early flowering plants are thought to have evolved in the great rift valleys between these two slowly diverging continents. New Zealand, as part of a large, now mainly submerged, crustal block, began separating from Australia and Tasmania at about 80 Ma, via a spreading ridge off the east coast.

But through all this rifting and separating, Australia remained firmly attached to Antarctica. Initial separation began about 96 Ma (mid-Cretaceous), when a rift and spreading ridge developed at the western end of the Great Australian Bight, from where India had previously departed. The spreading ridge slowly propagated eastwards through the Bight area, like a giant zipper, and a narrow band of new ocean crust was formed in its wake. But when the rift reached the Otway area, off SW Victoria, something strange seems to have happened, and it stalled. The Bass Strait area was directly ahead, and was the logical continuation for the rift, but it did not get there. There was considerable stretching and thinning of the crust along this line (fig. 1), and a large amount of subsidence to form three important basins — Otway, Bass and Gippsland. Indeed, these basins had been subsiding, and sediment was being washed into them, since probably the late Jurassic, as the two continents were slowly stretched apart. But actual separation of the two continents did not occur through this area, and I have surmised that this was due to the presence of two old ridges of Devonian granite that connect Tasmania to Victoria, like two strong arms. These are the Bassian Rise in the east, stretching from the Furneaux Islands through Deal Island to Wilsons Promontory, and the King Island Ridge in the west, connecting King Island to the Mornington Peninsula area (fig. 1). The upper parts of these ridges now form the hills and islands of granite that we see, but beneath this there are probably deep roots to more or less continuous granite masses which would have been very difficult to break apart. It is notable that the three basins are separated by the granite ridges.

So, the zipper jammed near the Otway coast, but the two continents continued to be pulled apart — nothing could stop that — and what followed was the making of Tasmania. A series of giant N–S-oriented tear faults (also called transcurrent or transform faults) broke through the crust, down what is now the west coast of Tasmania and across the corner of Antarctica — like tears in the fabric. This allowed a large slab of crust to slide away from Antarctica, slowly and inexorably, dragged northwards

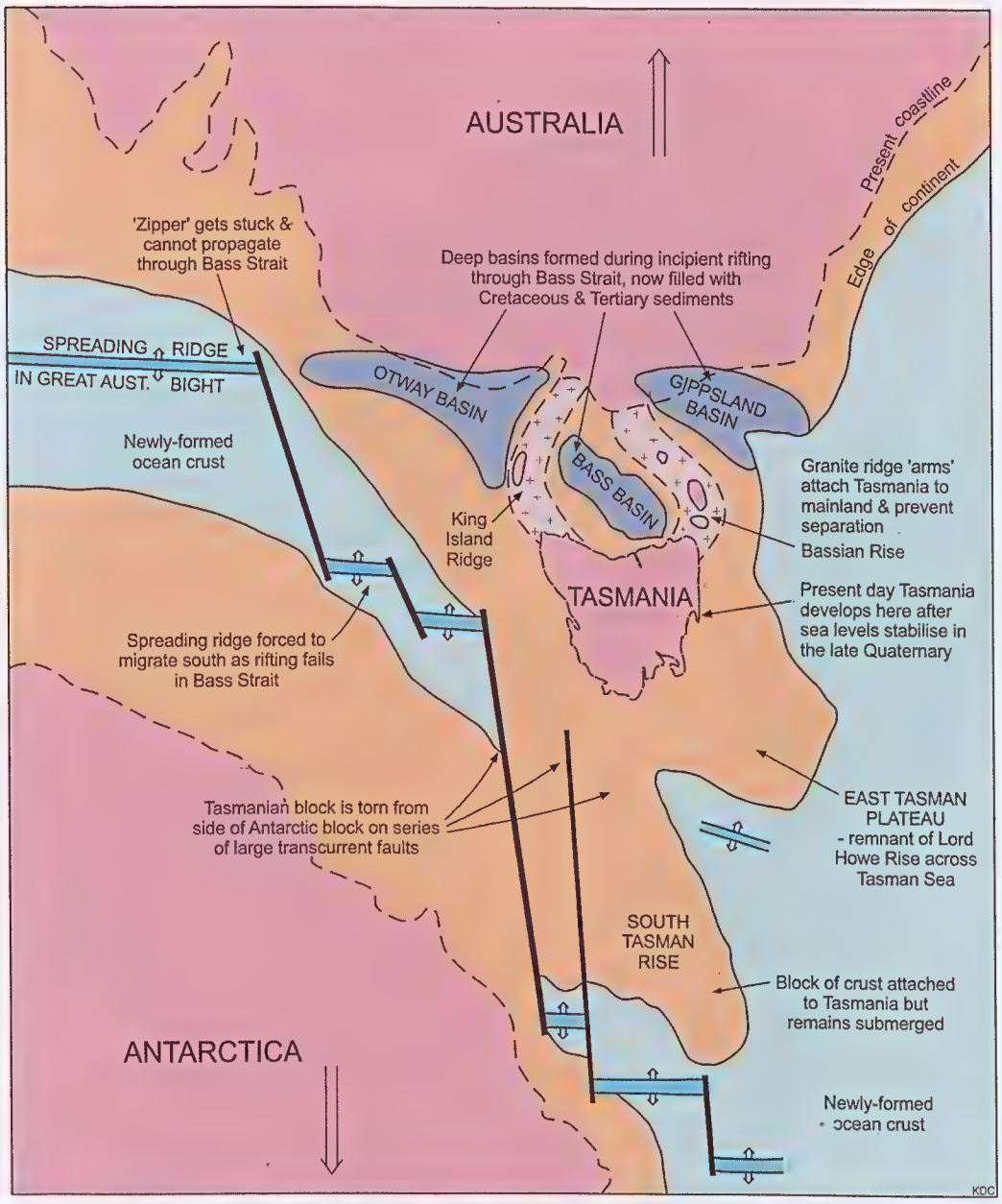
AUSTRALIA
Present coastline
Edge of continent
'Zipper' gets stuck & cannot propagate through Bass Strait
Deep basins formed during incipient rifting through Bass Strait, now filled with Cretaceous & Tertiary sediments
SPREADING RIDGE IN GREAT AUST. BIGHT
OTWAY BASIN
GIPPSLAND BASIN
BASS BASIN
Newly-formed ocean crust
King Island Ridge
Granite ridge 'arms' attach Tasmania to mainland & prevent separation
Bassian Rise
TASMANIA
Present day Tasmania develops here after sea levels stabilise in the late Quaternary
Spreading ridge forced to migrate south as rifting fails in Bass Strait
Tasmanian block is torn from side of Antarctic block on series of large transcurrent faults
EAST TASMAN PLATEAU - remnant of Lord Howe Rise across Tasman Sea
SOUTH TASMAN RISE
Block of crust attached to Tasmania but remains submerged
ANTARCTICA
Newly-formed ocean crust
KDC

FIG. 1 — The birth of Tasmania, 40 million years ago. As Gondwana is torn apart, and Australia is separating from Antarctica, the spreading ridge 'zipper' stalls at the western end of Bass Strait. Large transcurrent faults allow a wedge of crust, containing the future Tasmania, to be torn from the corner of Antarctica. There is considerable stretching and subsidence in the Bass Strait area, forming three separate basins — Otway, Bass and Gippsland. The two granite 'arms' probably hold Tasmania to the mainland. From Corbett (2019).

attached to Australia. This sliding took many millions of years — the rate was only about 5 cm per year — so that a land bridge was maintained between Antarctica and Australia for quite some time, enabling many plants and animals to have made the crossing. The final pulling away, and the formation of new ocean crust to the south of Tasmania — by the spreading ridge which had migrated southwards in this time — occurred about 35–40 Ma. When the link between South America and Antarctica was also broken, at about 30 Ma, Antarctica was left stranded and sea-bound at the South Pole. Seawater could now circulate all the way around it, without going to the tropics to be warmed, and Antarctica, which had previously had a temperate climate, began to cool.

This long wedge of crust, containing what was to become Tasmania when sea levels finally stabilised in the late Quaternary, was now carried north like a reluctant appendage, attached to the SE corner of Australia. Submarine surveys carried out by Geoscience Australia, Canberra, have produced dramatic images of this crustal wedge, and of the great linear fault scarps down the western side, to confirm this extraordinary 'caesarian birth' for Tasmania. As well as the Tasmanian section, there is a similar-sized block to the south, known as the South

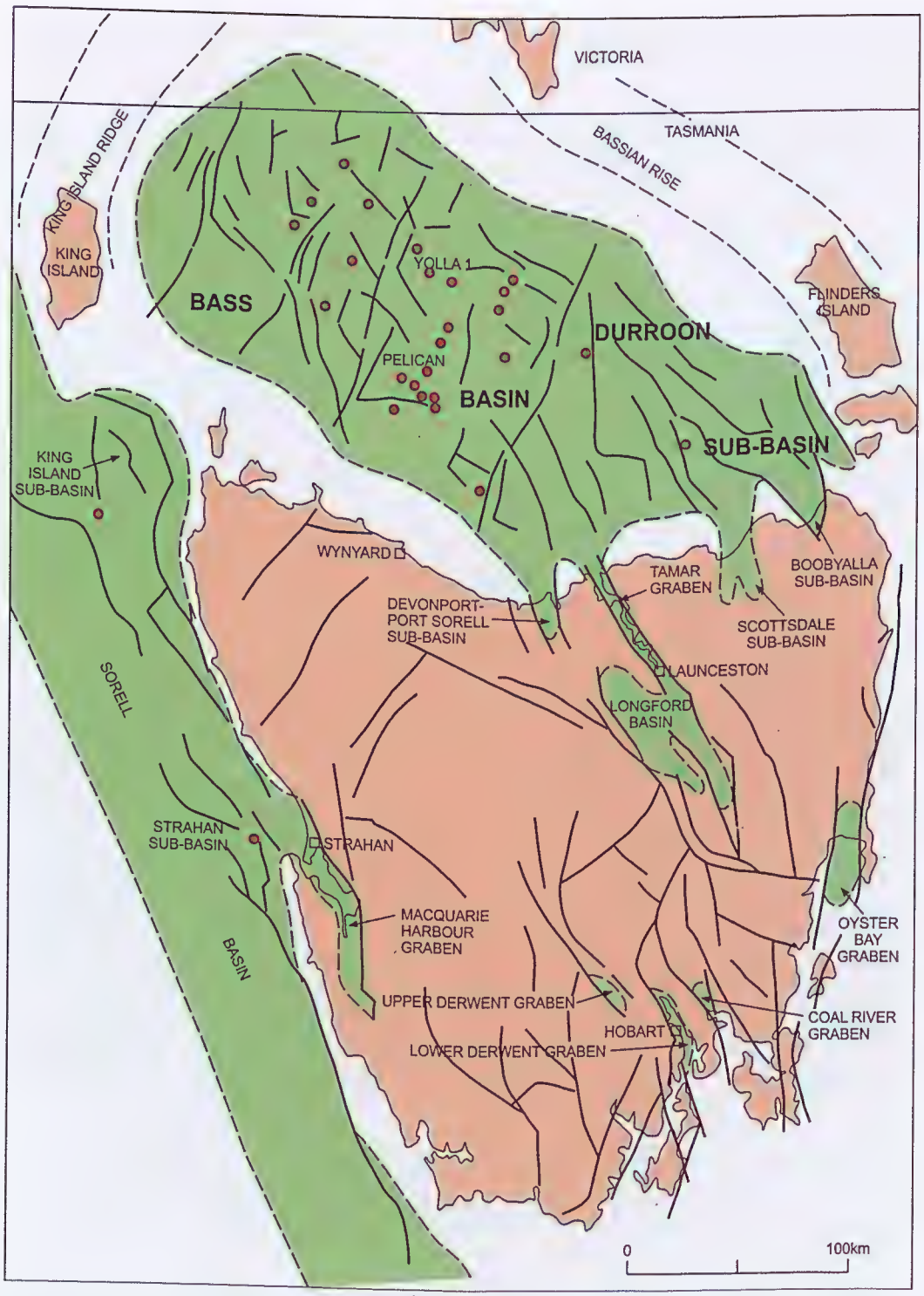

FIG. 2 — General outline of the Bass Basin and other Tasmanian basins and graben, and related major faults, formed by the crustal stretching and subsidence in the Cretaceous and Cenozoic related to the separation of Australia and Antarctica. Modified from Williamson *et al.* (1985), Seymour & Calver (1995), Stacey & Berry (2004) and Forsyth *et al.* (2014). Red circles are drill holes.

Tasman Rise, which is completely submerged beneath a kilometre or more of ocean, and also a projection to the east known as the East Tasman Plateau, which has a large submarine volcano sitting on it rising to a depth of 650 m (fig. 1). Several other volcanic seamounts are scattered around the ocean floor off SE Tasmania.

So it was that the wedge of crust containing Tasmania was wrenched away from the corner of Antarctica and carried slowly northwards attached to Australia — geologically a piece of Antarctica, as our abundance of dolerite attests, but now part of another continent. Truly a child of Gondwana. We have been drifting northwards at the rate of about 7 cm per year now for some 40 million years, and we are now separated from our 'mother' continent by some 3500 km of stormy ocean. Thus, we find ourselves living in the relatively balmy climes around 40° S, on a beautiful island which preserves many of the Gondwanan species which came with the island, while our counterpart to the south

is largely ice-covered. Plate tectonics, driven by the great slow-churning convection currents in the mantle, pays no heed to where continents and fragments thereof may end up.

Australia gradually became warmer and drier as it drifted north, and the temperate rainforests which had covered much of the continent until the Miocene gradually gave way to dry-tolerant vegetation types, containing eucalypts and acacias, and open woodlands and grasslands. The rainforests were forced to retreat to the moist eastern highlands to survive. Antarctica finally froze over about 5 million years ago, and the global Ice Age of the Pleistocene epoch began about 2.6 million years ago. This period was marked by multiple cold episodes (possibly as many as 20), or Glaciations, during which sea level was lower than present (by up to 130 m or so), alternating with warmer periods, or Interglacials, when sea level rose again. The present period, from 11,600 years ago, is an Interglacial, known as the Holocene.

THE BASS BASIN AND THE TASMANIAN RIFT VALLEYS

The stretching of the crustal wedge as it was dragged away from Antarctica in the Cretaceous and early Cenozoic affected not just the Bass Strait area but all the area which was to become Tasmania. Numerous faults and cracks developed, and sections of the crust subsided along these. Several rift valleys, or graben, were formed and infilled with sediment (fig. 2). Bass Basin was the major offshore structure, and had extensions onto northern Tasmania at the Tamar Graben, which itself connected to the larger Longford Basin to the south, the Devonport - Port Sorell Basin to the west, the Scottsdale Sub-basin, and the Boobyalla Sub-basin in the far North-East. The elongate Sorell Basin developed offshore down the west coast of Tasmania, with an onshore extension forming the Macquarie Harbour Graben through Strahan. Two small graben were developed in the Derwent Valley, at Hobart and in the Ouse-Gretna area, and the Oyster Bay Graben on the East Coast was related to a major fault along the eastern side of Freycinet Peninsula and through Schouten and Maria Islands.

The onshore basins and graben are mostly shallow, with a few hundred metres of sediment fill in most cases, but Bass Basin is a serious 'hole' in the crust, with an infill thickness of at least 10 km in places. Much information has been gained on the internal structure of the basin from the hundreds of kilometres of seismic surveys and the 38 wells which have been drilled in the search for oil (Baillie & Quilty 2014). The fault pattern controlling the subsidence has been complex and varied with time. The earliest faults, in the early Cretaceous, were the largest, dominated by NW-trending normal faults with individual displacements of many kilometres. These formed a series of one-sided or half-graben, down-thrown to the SW. Intersecting or terminating these was a second series of NE–SW-trending transfer faults (Etheridge *et al.* 1985). In the south-eastern part, towards Flinders Island, however, the stress pattern was somewhat different, and the half-graben here were down-thrown to the NE in what is known as the Durroon Sub-basin. The Jurassic dolerite formed the basement for the basin-fill over much of the area towards the Tasmanian side, but this must have changed somewhere under the central Bass Strait area, perhaps reflecting the ancient suture line where Australia became joined to Antarctica back in the Proterozoic.

For much of the Cretaceous and early Cenozoic periods (i.e., for about 100 million years) the Bass Strait area was a large alluvial plain, sprinkled with freshwater lakes at times, and fed by numerous large rivers, mostly coming from northern Tasmania (fig. 3). The ancestral Tamar was perhaps the largest of these rivers. I surmise that there must have been a major outlet river connected to the sea through a gap in the King Island Ridge to the NW of the basin. A very large thickness of sediment — up to 10 km or more in places — was washed into the rapidly subsiding Bass Basin during this period. My estimate of the volume of material suggests at least 100,000 cubic km (Corbett 2019), and others have suggested even more. This represents a huge amount of material eroded from the dolerite and underlying Triassic and Permian rocks, and from the older basement rocks of northern Tasmania. This deep erosion probably accounts for the small remnants of dolerite at peaks such as Mt Victoria, Ben Nevis, Mt Saddleback etc. in the NE, where all the intervening rock has been removed. This represents one of the great periods of erosion and stripping of Tasmanian rocks in our geological history.

The sediments were deposited by the rivers as sands, muds and gravels, in various alluvial, lacustrine and deltaic environments over time. The Bass Basin drill logs indicate that large freshwater lakes were present for significant intervals, e.g., Lake Koorkah in the Paleocene and Eocene (figs 3, 4). Peat swamps developed at times, as evident from the layers of lignite and coal in some of the drill sections. Conglomerates containing large boulders, particularly of dolerite, were deposited close to some of the fault scarps, and some of these have been drilled at the faulted margin of the Boobyalla Sub-basin near Gladstone. Others are seen along the margins of the Tamar Graben, particularly on the eastern side.

For most of its early life the Bass Basin–Bass Strait area remained cut off from the sea by the granite ridges to east and west, and only in the Oligocene, about 30 Ma, did a shallow bay form through a low area eroded in the King Island Ridge to the NW (fig. 4). This gradually deepened, and in the Miocene the strait was inundated by the sea, and shelly marine sands and limestones replaced the non-marine deposits across the whole area. The coastal outline of what we know as Tasmania today probably started to form at about this time in the Miocene, some 20 Ma. Bass Strait has remained a shallow sea (average depth 60 m) ever since, with a land bridge present along the Bassian Rise during low sea-level periods of the Pleistocene Ice Age (enabling the Aboriginal people to migrate to Tasmania). The Miocene coastal limestone deposits are also seen at several onshore localities along the north coast, such as King Island, Cape Grim, Temma and Fossil Bluff (Wynyard). These limestones are not seen within the Tamar Graben,

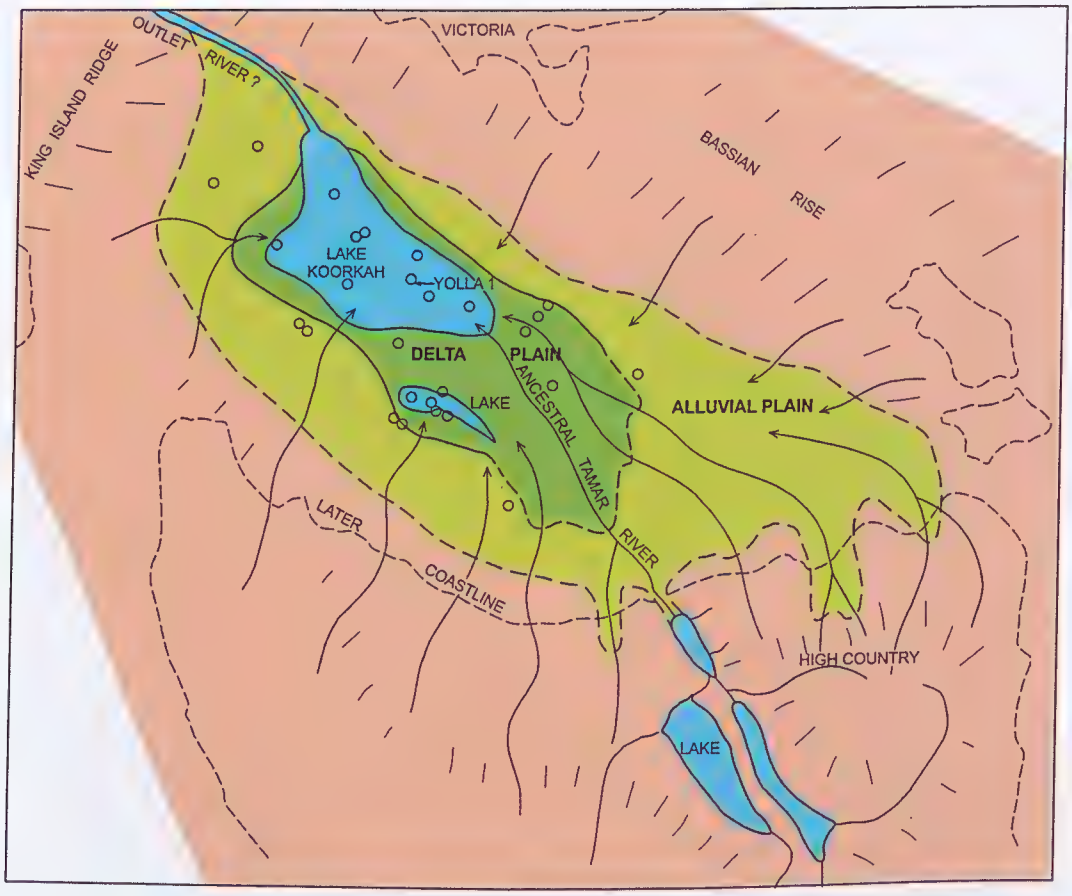

FIG. 3 — Generalised palaeogeographic map of the Bass Strait area in the early Eocene, about 50 million years ago, based mainly on drill hole information. A large alluvial delta plain, with freshwater lakes, covered much of the rapidly-subsiding Bass Basin area. The ancestral Tamar River was one of the major feeder streams, draining much of the central northern area of what was to become Tasmania. An outlet river to the sea through a gap in the King Island Ridge seems likely. Modified after Blevin (2003).

however, which may indicate a basalt barrier near the Tamar mouth, or possibly some uplift of northern Tasmania caused by a change in tectonic stresses in the Miocene (K.C. Morrison, pers. comm.).

GEOLOGY OF THE TAMAR GRABEN AREA

Earlier general descriptions of the geology of the Tamar–Launceston area have been provided by Johnston (1888; Tertiary (Cenozoic) beds and plant fossils), Carey (1947; geological mapping around Launceston and interpretation of the history, with diagrams), Longman (1966; general geology of Launceston area, with diagrams of structural development), Sutherland (1969, 1971; basalts of the Tamar area and how they relate to the geological development), Forsyth (1989; overview, with fossil ages), Sutherland *et al.* (2006; further dating of basalts, with overview), and Forsyth *et al.* (2014; overview). Sutherland (1971) gives a detailed list of references. An excellent series of detailed geological maps at 1:25,000 scale now covers the Tamar area (Low Head, Port Sorell N & S, Bell Bay, Beaconsfield, Lilydale, Exeter, Dilston, Launceston, Prospect sheets), as well as maps at 1:50,000 scale (Beaconsfield, Frankford, Pipers River, Launceston sheets), and a special series of landslide hazard maps at 1:25,000 scale. All of these are available from Mineral Resources Tasmania (https://www.mrt.tas.gov.au/home). This study is based on all this previous work, overlaid with some of the author's interpretations.

The geology of the Tamar area is fairly complex in detail because of the many rock type changes (fig. 5). The oldest rocks are of Proterozoic (Precambrian) age, in the Asbestos Range–Badger Head area. There are Cambrian and Ordovician rocks at Beaconsfield, including ultramafic rocks, limestones, and an important gold deposit, and there are Ordovician to Devonian age sandstones, mudstones and slates to the east of the Tamar. These rocks form the basement to the rocks considered here, and while their structural features and weaknesses may well have influenced the locations of the Cenozoic graben, they are not considered further. The Tamar geology is essentially dominated by two major rock units (fig. 5). The first is the Jurassic dolerite (with its associated underlying Permian and Triassic sediments), which forms the two arms which enclose the Tamar Valley. The dolerite rises eastwards in a series of fault steps to the peaks of Mt Arthur and Mt Barrow (and Ben Lomond further south). The second is the Cenozoic (Tertiary) sediments with their intercalated basalts, which fill the graben and extend into some of the side valleys and across to the Longford Basin. The western dolerite 'wall' of the Tamar is generally lower than that to

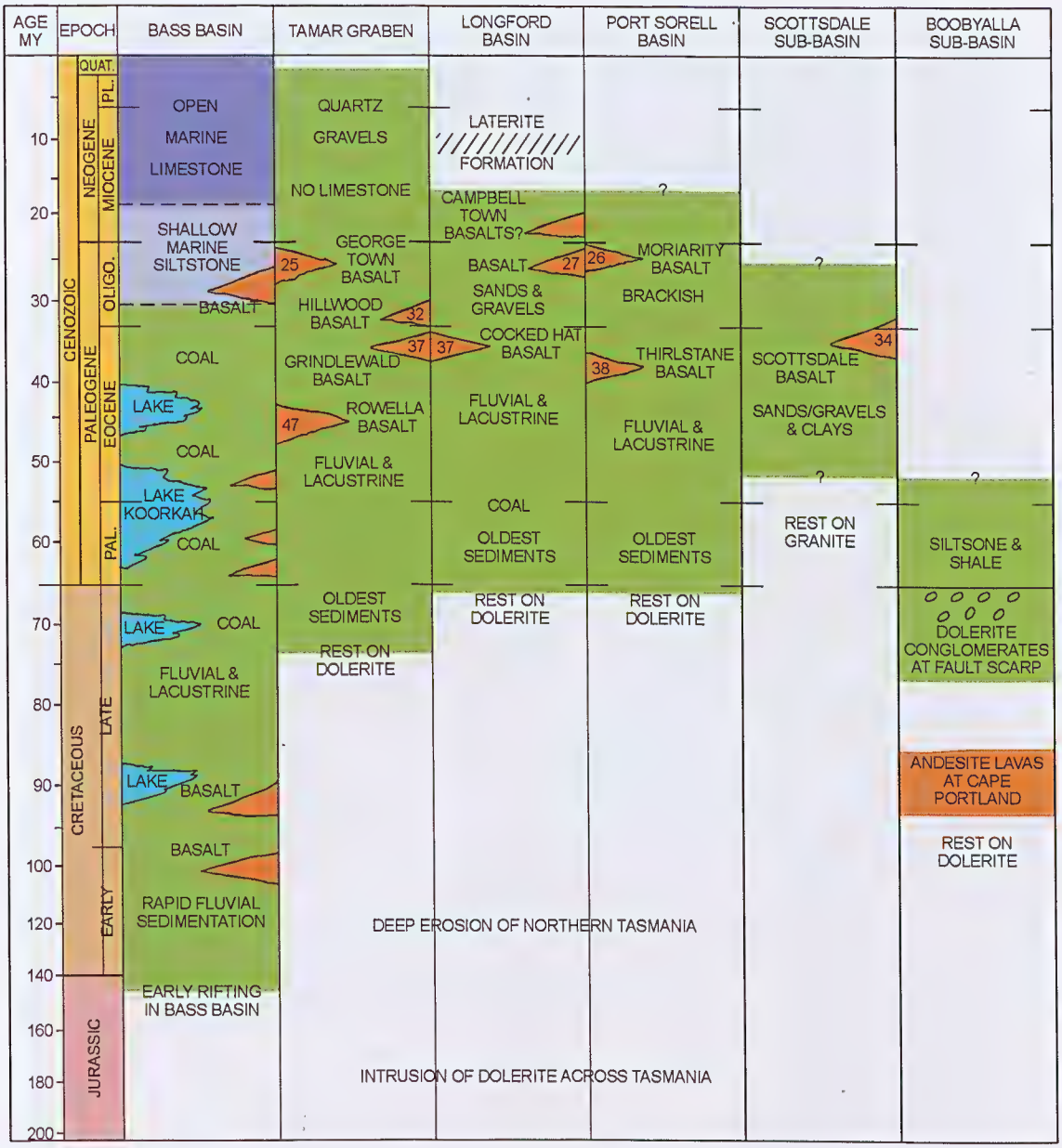

FIG. 4 — Correlation chart for the sediments and basalts in the Cretaceous–Cenozoic basins of northern Tasmania. Based mainly on Baillie & Quilty (2014) and Sutherland *et al.* (2006). Numbers are dates (in million years) on some of the basalts.

the east and is 'breached' by both the river and the Tertiary sediments in the Beauty Point area.

The dolerite was originally intruded into the Permo-Triassic mudstones and sandstones, about 180 Ma, as a sub-horizontal sill, around 200 m thick. The hot molten magma came up through cracks in the old folded rocks, then pushed sideways through the horizontally layered Permian and Triassic sediments, usually a few hundred metres below the surface. The overlying sandstone was quickly eroded away during the mid to late Jurassic, leaving the hard dolerite to form most of the flattish landscape surface — as presently seen on the Central Plateau and Ben Lomond. Laterite and bauxite were developed on the dolerite surface due to deep weathering, possibly at several stages during the Cretaceous and Cenozoic, and remnant patches of these are widespread. The dolerite of the flanking hills along the Tamar is a heavy, hard rock, known colloquially as 'bluestone', which is difficult and expensive to excavate. It contrasts greatly with the soft sediments of the valley floor. Boulders of dolerite are commonly used in landscaping.

The stretching, rifting and faulting which formed the Bass Basin in the late Jurassic and Cretaceous also affected the Tamar area, and other parts of Tasmania as mentioned. The dolerite surface was broken into a series of mainly NW-trending fault blocks, and much of the land surface subsided, with the maximum subsidence being in the Longford area and along the Tamar. Areas to the side of this remained elevated, to form the present Central Plateau and Ben Lomond–Mt Barrow highlands. There appears

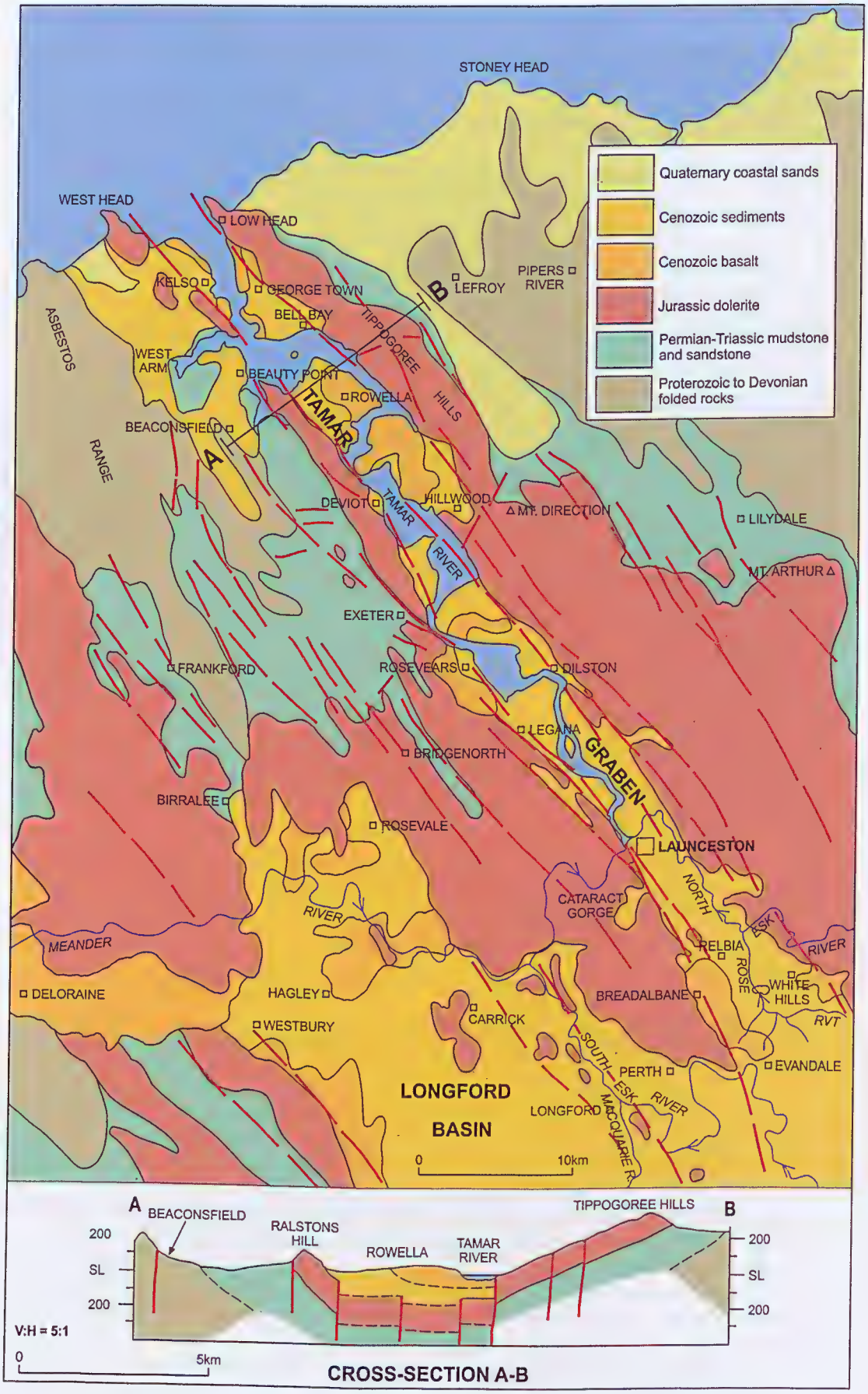

FIG. 5 — Simplified geological map of the Tamar–Longford area. Red lines are faults. Modified after McClenaghan *et al.* (2011), with additional fault locations from Blake (1959), Longman *et al.* (1964), Sutherland (1971), Gulline *et al.* (1973), and Gee & Legge (1971).

to have been an asymmetry in the stretching, however, and virtually all the fault blocks through the Launceston–Longford area were tilted to the SW and down-thrown on the SW side. These are referred to as half-graben or one-sided graben (as opposed to normal graben, where both sides are down-thrown). As a result of this pattern of faulting, the dolerite occupies most or all the surface, as seen through the Mt Arthur–Launceston–Carrick area (fig. 5), except where covered by the younger Cenozoic deposits. The sense of this fault pattern is indicated by the cross-section on Figure 6 (from Calver & Forsyth 2005).

The nature of the faulting changes about halfway along the Tamar Valley, however, where the fault blocks on the western side now tilt and down-throw to the east, bringing Permian rocks to the surface through the Exeter–Frankford area (fig. 5). The eastern fault blocks, as at Tippogorree Hills, continue to tilt and down-throw to the west (drilling has confirmed this (Boronowski & Morrison 2010)), so that the Tamar Valley now appears to be a normal two-sided graben. The change is marked by a pronounced 'side-step' in the valley in the Hillwood area, where the eastern dolerite 'wall' steps east about 2.5 km. The reason for this side-step and change is not well understood.

The Cenozoic sequence consists of the soft Paleogene sediments, in horizontal beds, and the much harder and more prominent basalts which occur at several levels (fig. 5). Total preserved thickness of the combined sequence is of the order of 400 m, but it is likely that a great deal has been eroded away over time, and the original thickness may have been considerably more. It is very likely, indeed, that much more sediment has been eroded away, and carried out into the Strait, than is now present. The bottom of the sequence in the Tamar River area is known only from a few scattered drill holes. The deepest known part is in a drill hole at Bell Bay, where the base is 250 m below sea level, while a drill hole near Launceston (Englewood) shows the base at 160 m below sea level. Both intersections show the sediments sitting on a dolerite basement. Plant spores show the basal Englewood beds to be of late Cretaceous age, whereas those at Bell Bay are somewhat younger, of Eocene age (Forsyth *et al.* 2014). This probably indicates that the older sediments downriver have been completely eroded away and carried further out. The sediments occur in side valleys up to 200 m above river level in places, suggesting that during the periods of maximum deposition, at least some of the lower dolerite hills would have been covered with sediment, later removed by erosion. It is likely that sediment deposition within the graben has been highly sporadic over time, with periods of erosion and flushing alternating with periods of build-up.

The sedimentary beds are generally poorly exposed, but are seen in various road cuttings and excavations, and in a few natural foreshore cliffs and outcrops. They typically consist of brownish to yellowish clays, sands and gravels, with siliceous gravels present in some upper parts of the sequence, and boulder conglomerates — mostly of dolerite — in places. Plant fossils, in the form of leaf and wood impressions, can be found in places, and bands of lignite (poor-quality brown coal), and laterite (ironstone) are also present. Shells of freshwater mussels have been found in the beds in the Spring Bay–Batman Bridge area. The oldest beds preserved are late Cretaceous; Eocene sediments are perhaps the most abundant, while the younger dated beds are Oligocene and Miocene (fig. 4). Some of the upper quartz-rich gravels are much younger, probably Quaternary, particularly Pleistocene. Holocene or recent sediments are seen in the form of estuarine and alluvial mudflats along the present river in many places. The Cenozoic sediments represent a variety of fluvial, lacustrine, deltaic and probable fault scarp talus deposits, and are all essentially related to a long-lived river system. The Longford Basin contains a similar but thicker sedimentary sequence, with the deepest section (800 m) against the Bracknell Fault at the SW margin (Forsyth *et al.* 2014).

Basalts are a prominent feature within the Tamar Graben, with major flows, or successions of flows, present around George Town, Rowella to Hillwood, Grindelwald to Windermere (including Bradys Lookout), and south of Launceston in the Breadalbane–Evandale–White Hills area. The basalt units are up to 100 m or so thick, and are, or were, intercalated within the sedimentary beds. Some of them form prominent bluffs. Sutherland (1971) and Sutherland *et al.* (2006) give excellent descriptions of the basalts, which include some coarse-grained types resembling dolerite. The basalts have been dated to either Eocene or Oligocene (fig. 4), but the ages are spread randomly geographically. The oldest, at about 47 Ma (million years ago), is the Rowella Basalt, followed by the Grindelwald Basalt (37 Ma), which is the same age as the Breadalbane or Cocked Hat Basalt. Then follows the Hillwood Basalt (32 Ma), and the George Town Basalt (25 Ma).

The basalts appear to have been erupted from faults within and along the margins of the graben, and in some cases have overlapped onto the adjacent dolerite ridges. Contacts between the basalts and the softer underlying sediments are highly irregular in some cases and have been prone to undercutting by the river at times in the past. This has caused significant collapse of the basalt to form piles of large disoriented blocks in some places, such as Bradys Lookout (Sutherland 1971). The George Town Basalt probably extends offshore as far as Hebe Reef.

It seems likely that the eruption of the basalts within the confined valley of the Tamar would have dammed the river to create at least a temporary lake, and perhaps diverted the river. Sutherland (1971) has suggested that the basalt eruptions in the Bell Bay–George Town area might have diverted the ancestral Tamar westwards over the low confining dolerite ridge and through the Beauty Point–West Arm area into the broad valley between West Head and Badger Head, giving the Tamar a different outlet to the coast. This possibility is difficult to evaluate, but there are Permian rocks exposed around the northern foreshore of West Arm (Gee & Legge 1971), with no indication of an old river channel, and it is difficult to see what might have re-diverted the river back into the present channel. In the Hillwood–Rowella area, the river has apparently been able to cut a new channel over and through the basalt, without leaving the constraints of the graben.

A much clearer example of major river diversion is that caused by the large basalt mass in the Breadalbane–Evandale–White Hills area (fig. 5). This situation was recognised many decades ago and may have been first reported by Nye (1932). It was discussed in detail by Carey (1947) and noted by most subsequent authors. The original South Esk River would have continued its northward path from Evandale, to join the North Esk somewhere near where the latter enters the main valley at Corra Lynn. The large eruption of basalt some 37 Ma, in the late Eocene, would have filled the valley, causing a large lake to form which would have extended southwards for many kilometres. The South Esk was tipped westwards, past the positions of Perth and Longford, to join the Macquarie and the Meander and flow through a narrow gorge carved through the dolerite — the present Cataract Gorge. It is possible that the original Macquarie–Meander system may have already been taking this course through the dolerite, and that the addition of the South Esk has accelerated the down-cutting process.

The second interesting aspect of this diversion story concerns the Rose Rivulet, the relatively small tributary of the North Esk which now occupies the route formerly taken by the South Esk to the north of Evandale. This stream has cut a fair-sized valley in the Cenozoic sediments and through much of the basalt mass, between Relbia and White Hills, and its headwater tributaries are steadily eroding their way south towards Evandale. As described by Nye (1932) and Carey (1947), the great flood of April 1929 raised the level of the South Esk at Evandale to within 'a few feet' of the divide between the river and a tributary of Rose Rivulet. This may be somewhat exaggerated, but even so, the prospect of a huge flood causing South Esk water to pour over the divide into Rose Rivulet, and for the consequent down-cutting to divert most or all of the river into its old course towards the North Esk, seems a real possibility. The consequences of this for Launceston would be quite dramatic.

THE GEOLOGY OF LAUNCESTON

Launceston city extends across the floor of the sediment-filled valley, here about 3 km wide, and onto the flanking dolerite hills (fig. 6). The western side of the graben is well defined by the Trevallyn Fault, which runs along the foot of the Trevallyn slope. It is intersected by the Glen Dhu Fault, which runs through the First Basin area of the Cataract Gorge. The eastern side of the graben is less well defined, with several likely faults involved, and there is 'spillage' of the Tertiary beds into several side valleys. The city centre is situated in the central part of the valley, near the junction of the North and South Esk rivers, with the suburbs of Inveresk, Mowbray, Newnham and Alanvale on the northward extension of the valley, and Newstead, Punchbowl and Norwood on the southern extension. Suburbs such as Riverside and Trevallyn are mostly located on the western dolerite hills, while a number of places are developed on small valleys floored by Cenozoic sediments within the dolerite hills both east and west (e.g., Ravenswood, Waverley, St Leonards, Prospect). The meandering North Esk, with its associated muddy alluvial wetlands, extends along the eastern side of the valley for about 10 km from Corra Lynn. The area of young wetlands expands where the North Esk enters the Tamar, and these muddy unconsolidated sediments occupy nearly half the width of the valley northwards to the Tamar Island area. The suburb of Inveresk has been developed on these Quaternary estuarine sediments.

A cross-section from Glen Dhu to Waverley has been constructed by Calver and Forsyth (2005) and shown in Figure 6. It is drawn to scale and shows how shallow the Cenozoic sediments are in comparison to the width of the valley. It suggests that the maximum thickness of sediments is only about 250 m adjacent to the Trevallyn Fault, in what could be a narrow two-sided graben structure. Elsewhere, the thickness is only about 100 m or less. The dolerite basement projects through the sediments in several areas around Punchbowl, Youngtown and Kings Meadows.

The soft, clay-rich Cenozoic sediments are prone to landslides on slopes as low as 7°, and places such as South Launceston, Grindelwald and Beauty Point have had significant problems (Mazengarb *et al.* 2014). The most seriously affected area has been Lawrence Vale, at South Launceston, where a single large slow-moving landslide has destroyed about 42 houses from the late 1950s to the 1970s (Ezzy & Mazengarb 2007). Information on these and other Tasmanian landslides is available on the Mineral Resources Tasmania website.

Cataract Gorge

The Cataract Gorge, where the South Esk River tumbles through a rugged dolerite-walled gorge for several kilometres on the western side of Launceston, is the city's most famous landmark and visitor attraction. The several stages involved in the formation of the gorge are summarised as follows:

Crustal stretching in the Tamar area related to the formation of the Bass Basin during the separation of Australia from Antarctica, mainly during the Cretaceous Period (140–70 Ma), causes a series of NW-oriented faults and related joints at various orientations in the Jurassic dolerite. Any fault-related earthquakes would have occurred at this time.

Damming of the South Esk River by basalt flows at Evandale in the late Eocene, about 35 Ma, forces the river westward to join the Macquarie and Meander to cut the gorge through the hard dolerite, mainly following prominent joint directions. These major joints typically consist of a group of parallel cracks which break the dolerite up into movable pieces. The First Basin is developed at a particularly broken area where two major joint sets intersect with the Glen Dhu Fault.

Further cutting down through the dolerite has continued for the past 30 million years, with most of the erosion probably related to large flood events.

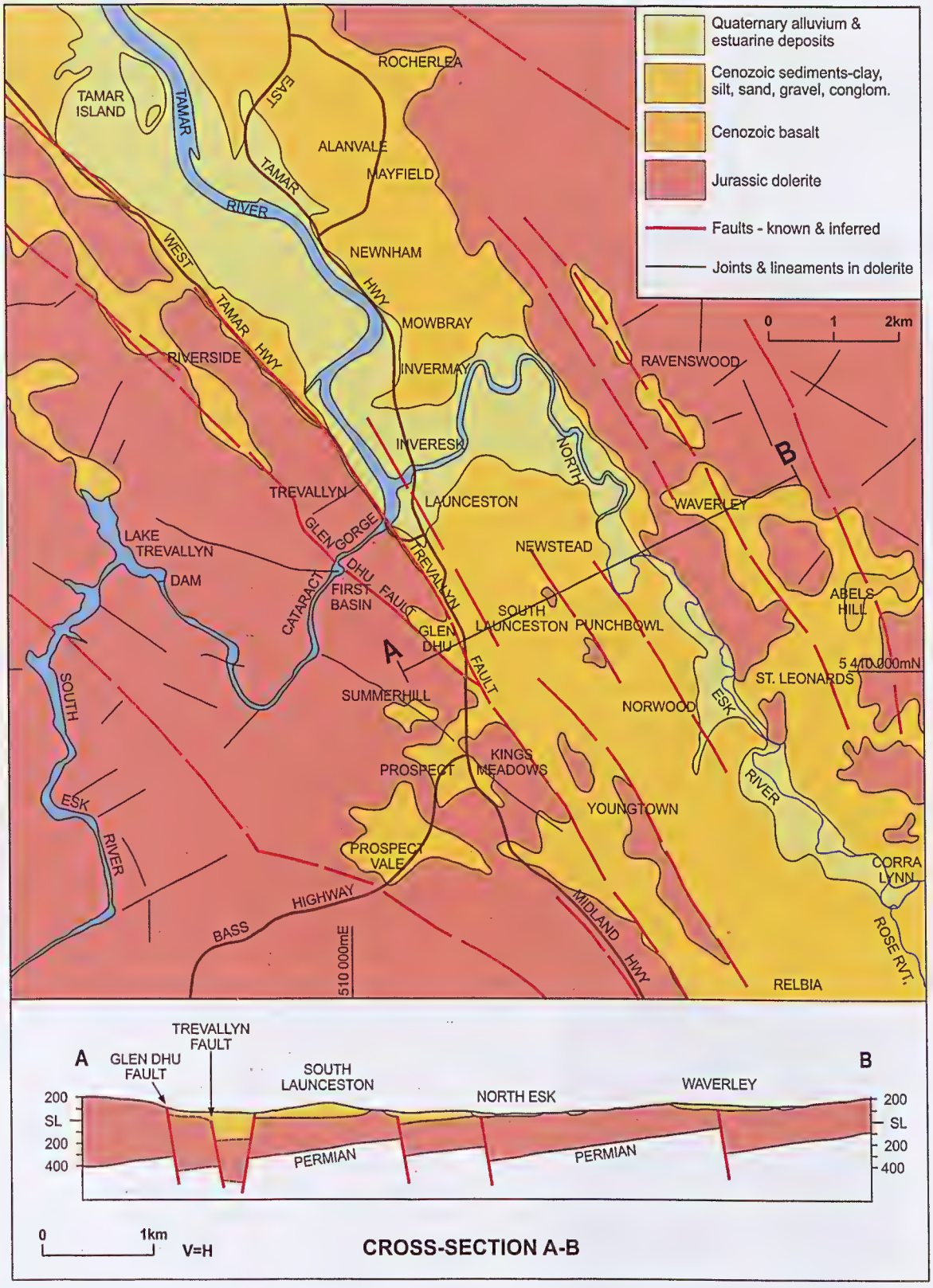

FIG. 6 — Geological map of the Launceston area. Based mainly on Calver & Forsyth (2005), with additional joints/lineaments locations from Longman *et al.* (1964). Cross-section AB is from Calver & Forsyth (2005).

ACKNOWLEDGEMENTS

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(accepted 21 Jan 2021)

FROM IODINE DEFICIENCY TO EXCESS: THE TASMANIAN THYROTOXICOSIS EPIDEMIC OF THE 1960s

by Paul A.C. Richards, AM

(with three text-figures and one plate)

Richards, P.A.C. 2021 (2:vi): From iodine deficiency to excess: The Tasmanian thyrotoxicosis epidemic of the 1960s. *Papers and Proceedings of the Royal Society of Tasmania* 155(1): xx–xx. ISSN: 0080–4703. Hon. Research Associate, University of Tasmania, Private Bag 51 Hobart, Tasmania 7001, Australia. Email: pacrichards1@bigpond.com

Even though iodine deficiency in Tasmania had been known since the 1830s no full account of the thyrotoxicosis epidemic of 1966–67 has ever been recorded. This personal narrative tracks the history of this epidemic in Tasmania during the 1960s, when it first appeared as iodine deficiency, then as iodine excess, how it was formally recognised and the events leading to its eventual treatment. The addition of iodine into the diet of Tasmanians, initially in bread and then unwittingly through use of iodophors in the dairy industry, resulted in a sequence of events that required unravelling by medical practitioners new to the field but aided by experts from elsewhere. The Tasmanian thyrotoxicosis epidemic was, and continues to be, cited in the annals of the scientific literature as an important medical case study.
Key Words: thyrotoxicosis, excess iodine, Tasmanian epidemic, bread fortification, iodophors, dairy industry.

BEGINNING OF THE EPIDEMIC

Launceston over the years has experienced major and minor outbreaks of diseases which have included typhoid, smallpox, measles, diphtheria, the influenza pandemic 1919, polio 1937 and 1950s, HIV and more recently the COVID-19 pandemic of 2020. Iodine deficiency in Tasmania had been known since the 1830s (Parker 1833) and by 1949 the prevalence of iodine-deficient goitre was being considered a serious public health problem (pl. 1). Iodised salt had been used successfully to treat iodine deficiency in several countries but at this time was not considered a practical solution for use in the Tasmanian food distribution system. Nor was it the preferred method of supplementation recommended by the principal researcher at the University of Sydney Dr F.W. Clements, who by 1947 had already successfully reduced the incidence of goitre in Canberra school children using potassium iodide tablets. Tasmanian authorities therefore decided to address the iodine imbalance using the tablet method and in the 1950s, through the Commonwealth Government and the public health system, 10-milligram tablets of potassium iodide were made available to school children for their weekly consumption. While many Tasmanians may still remember being required to take a small white 'goitre tablet', the consensus was that the tablets tasted unpleasant and periodic surveys conducted over 16 years showed that tablet distribution and compliance by children was relatively poor. Nevertheless, there was a gradual fall in the incidence of goitre from the late 1950s onwards, followed by a definite improvement between the years 1960–65, and this was attributable to the tablet supplement.

PLATE 1 — Two Tasmanian women displaying enlarged goitres (from the private collections of Mrs Valerie Crann and the late Dr Marita Bardenhagen).

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In April 1966, the Department of Health decided to replace the potassium iodide tablets and instead required iodate to be added to bread made in Tasmania. Potassium iodate, 4 ppm dry weight (designed to produce an intake of 100–150 μg iodine per day), was from then on substituted for potassium bromate as a bread improver used in bread making in the state. The health outcome of adding iodine to bread was immediately obvious and within three years the rate of endemic goitre had been reduced dramatically. By 1967 it was thought that iodised bread had satisfactorily corrected Tasmania's iodine deficiency and this was confirmed through measurement of urinary iodine excretion, plasma inorganic iodide and radioiodine uptake. Tasmania's iodine imbalance had been addressed, or so it was thought.

Within a matter of months, the situation changed. Iodine levels, now regarded as normal, began to rise as more and more people began presenting at thyroid clinics and private medical practices around the state. They were displaying a range of previously unseen symptoms and so it was that Tasmania's iodation epidemic had begun.

Early identification

The Launceston Thyroid Clinic had operated from 1943 and was first established by Dr John Grove Snr with Alan Pryde as surgeon to the clinic until his death in 1959. Dr Grove was joined in 1955–57 by a young resident medical officer, Dr George Vidor, who took over the clinic when Dr Groves retired in 1966. By September 1966, about five months after iodation began, Dr Vidor, reported seeing more thyrotoxic patients than usual and by 1967, at the height of the epidemic, Dr John Stewart was invited to join the clinic to help with the workload. When the flood of thyrotoxic patients threatened to overwhelm the clinic, Dr Vidor recruited me, his partner in general practice at the time, as his Honorary Clinical Assistant thus beginning a partnership in thyroid studies that lasted virtually until his death in 2004. Dr George Vidor became my mentor in diagnosing and treating thyroid disorders but at the beginning of this epidemic we were all novices seeking guidance with this unfolding set of events.

The Launceston Thyroid Clinic had an extremely good record-keeping system, which was linked with the Department of Nuclear Medicine, formerly the Isotope Department of the Peter MacCallum Clinic established in 1950. These records established a sound baseline incidence pattern for comparing 1950–65 with the sudden increase in the number of cases presenting to the clinic in 1966. Good referral patterns, clinical criteria and established evaluation were essential components of what was to be an unprecedented epidemic of iodine induced thyrotoxicosis, with very few cases, if any, bypassing the system. In contrast, the Royal Hobart Clinic had only been supervised for a short period by a specialist endocrinologist — Dr Roger Connolly — and up until 1965 accurate figures were not available on all presenting cases.

Dr Vidor contacted Dr Connolly and several endocrinologists in Victoria for advice. He was soon referred to Basil Hetzel, Professor of Medicine at the University of Adelaide and already eminent in the field of iodine deficiency. When told of the situation in Tasmania, Professor Hetzel immediately understood its significance and took over testing the blood from Launceston thyrotoxic patients in his own laboratory and provided the essential early guidance to medical practitioners.

Iodine-induced thyrotoxicosis had been known since the late nineteenth century but was usually described in individuals who were given large doses of iodine for the treatment of goitre or received large doses of iodine incidentally, such as in radiological contrast media. In epidemic form following correction of iodine deficiency it had been suspected in the USA in the 1920s and in Holland in the 1940s, but the numbers were not large, and the risk not taken seriously. Bread iodation since then in Canberra had had no apparent adverse effect and it was generally agreed that correction of iodine deficiency could do only good. The experience in Tasmania was the first irrefutable evidence of iodine-induced thyrotoxicosis in response to correction of iodine deficiency with modest doses of iodine. It could be described as a first for Tasmania and it was obvious that the epidemic demanded thorough detailed study.

TRACKING THE EPIDEMIC

Whether the dose of iodine was excessive was answered by measurement of urinary iodine in adults and by dietary surveys. This work was carried out by the Tasmanian Department of Public Health and showed no evidence of excessive dietary iodine. The iodine intake of Tasmanians had been increased only to a level that was considered 'normal' and, compared to many naturally non-deficient areas, was quite modest.

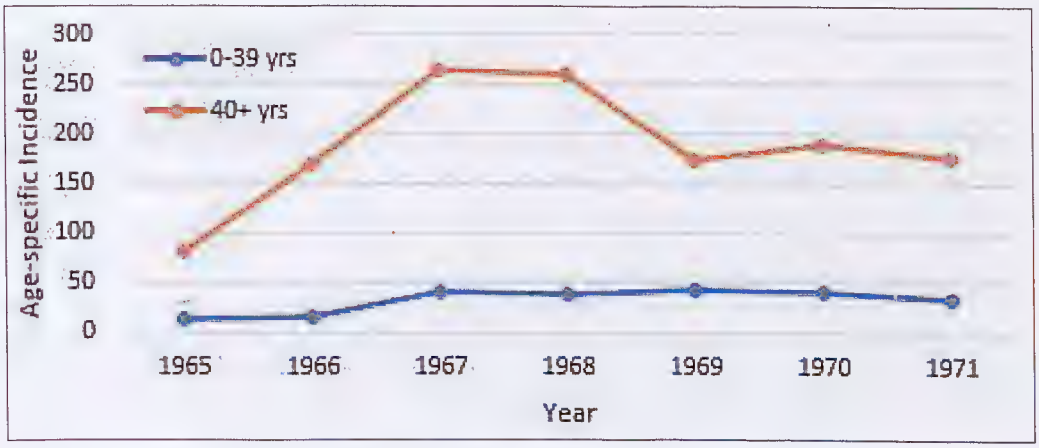
Those most at risk were older people, especially those with pre-existing goitre. Comparing the six years before iodation of bread to the six years after, the factor of increase in those below 40 years of age was x1.6 but in those aged over 50 years was x3.8.

Figure 1 indicates the age-specific incidence of thyrotoxicosis per 100,000 (1965–71) of two separate age groups: 0–39 years and 40+ years. The graph shows that thyrotoxicosis is more common in older people suffering from Graves' disease in a moderately iodine deficient environment when there is an excess of iodine supplementation.

In Figure 2 the sex-specific incidence of those undergoing treatment is shown for northern Tasmania during the period 1960 to 1994, by which time the epidemic had subsided.

It is interesting that prior to the epidemic, the sex-specific incidence of thyrotoxicosis was about 2:1; however, following the iodination of bread and other dietary supplements, this incidence peaked in 1967, almost 9:1 more prevalent in females, confirming a sex bias for this disease which has been well-documented by others.

During this period the incidence of thyrotoxicosis was mirrored by the growing number of patients treated with radioactive iodine.



Age (years)	1965	1966	1967	1968	1969	1970	1971
0–39	12.8	16.4	41.3	37.6	43.3	39.4	33.7
40+	81.4	170.2	265	259	174	190	175

FIG. 1 — Age-specific incidence of thyrotoxicosis per 100,000 (1965–71) of two separate age groups: 0–39 years and 40+ years.

The pathological mechanisms were not so easily determined but it was fortunate that the epidemic occurred at a time when the study of the thyroid was at an exciting stage of discovery. It was only six years earlier that Duncan Adams of Christchurch had published his discovery of the long-acting thyroid stimulator (LATS) in the blood of thyrotoxic subjects. This led ultimately to the recognition that Graves' disease was an autoimmune disorder in which abnormal antibodies stimulated the thyroid into overproduction of thyroid hormone and related antibodies caused the characteristic eye changes. LATS is not found in patients with toxic nodular goitre.

Furthermore, in the 1960s advances in technology were making it possible to study thyroid disorders in greater detail than previously. Techniques for the direct measurement of thyroid hormones and thyroid-stimulating hormone (TSH) in the blood made the diagnosis of thyrotoxicosis easier and more precise and the development of thyroid scanning made it possible to detect autonomous nodules. Thus, for the first time, it was possible to determine with a high degree of certainty which thyrotoxic patients had Graves' disease and those with toxic nodular goitre.

Our studies over several years, involving the cooperation of many researchers from interstate and overseas who applied their new laboratory techniques to blood from Tasmanian patients, led to the conclusion that iodine-induced thyrotoxicosis is not a unique disease. Patients suffering from it can all be shown to have either Graves' disease or toxic nodular goitre; there is no third type of thyrotoxicosis. As previously explained, iodine deficiency causes goitre in children and adolescents. In adult life these goitres become nodular and some of the nodules can, after decades, become autonomous. Autonomous thyroid tissue has lost its dependence on TSH to produce hormone; it secretes thyroid hormone without regard for the need for it. The amount of thyroid hormone produced

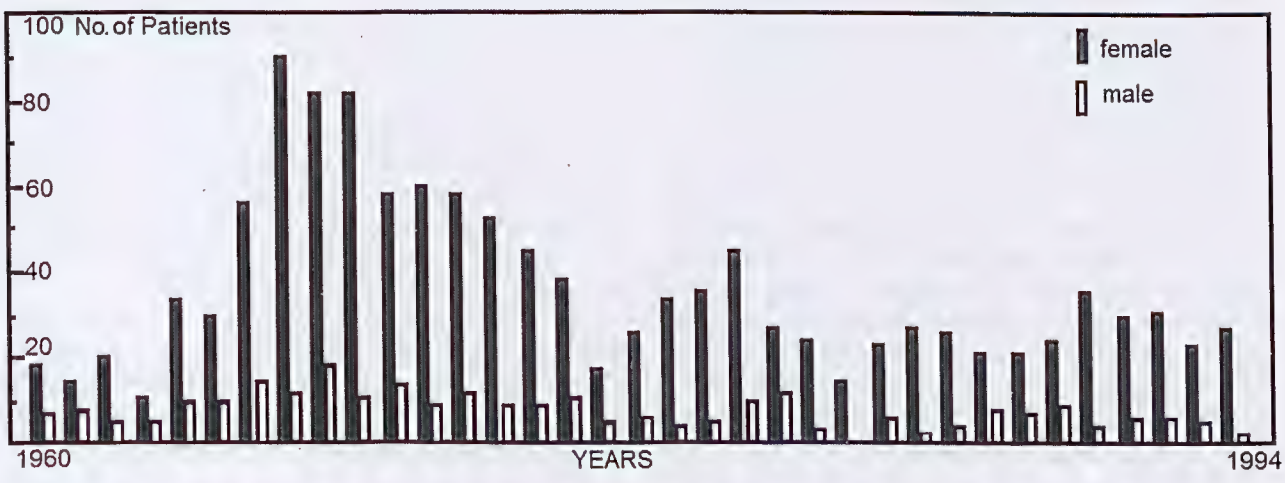


FIG. 2 — Number of patients (males and females) receiving radioactive iodine treatment for thyrotoxicosis in northern Tasmania from 1960 to 1994.

is determined by the amount of autonomous tissue and the availability of iodine.

In a population exposed to iodine deficiency for many years there will be people who, while not unwell, have autonomous thyroid nodules producing hormone in a manner not subject to normal control. There will also be some who have uncontrolled thyroid activity because of Graves' disease but in whom thyroid hormone levels are still normal. If iodine deficiency is relieved the additional iodine allows the uncontrolled thyroid tissue in both groups to produce excess hormone causing thyrotoxicosis. Because nodular goitre is more common in iodine-deficient populations than is subclinical Graves' disease, most iodine-induced thyrotoxicosis is in the form of toxic nodular goitre. This explains the preponderance of older patients in the epidemic.

The duration of the epidemic seemed as if it would be easily determined simply by waiting until it stopped. But, as we eventually discovered, this was not the case.

WHAT WAS THE CAUSE?

The cause of the epidemic was at last revealed in April 1967 when Basil Hetzel met Dr Heather Gibson, the Chief School Medical Officer, to discuss arrangements for a urinary iodine survey which the Health Department had requested and she told him of the bread iodation. Professor Hetzel visited Launceston soon afterwards, studied our figures for thyrotoxicosis to assure himself that the increase was real and then proclaimed to us the condition was known as "Jod Basedow". Jod Basedow Syndrome (iodine-induced thyrotoxicosis) could only be correlated with high levels of iodine intake in the Tasmanian diet (Connolly 1971á, b, 1973) and so the link was made to bread.

While the decision by health authorities to require the iodine supplement in bread was for good health reasons, this was not widely known by the public. When the thyrotoxicosis epidemic eventually unfolded, it led to heightened public suspicion at the authority's motivation especially at a time when the anti-fluoridationists were campaigning against mass medication. As is so often the case when the facts are withheld, speculation concerning the motives for Government secrecy soon led to scurrilous rumours emerging, all of which were proven to be false.

While the link with bread had been made, the cause of the epidemic was in fact not so straightforward. The mean thyroid uptake of radioactive iodine-131 during the period in which the incidence of goitre declined (1960–65) was reflected in the euthyroid patients presenting to the author's department suspected of thyrotoxicosis over the same period. There is no doubt that improvement in the reduction in goitre in the period 1960–65 was attributable to the following range of factors.

In 1960 new shipping services commenced with the Bass Strait ferries bringing foodstuffs into Tasmania including fruit, vegetables, milk and other manufactured goods that had been produced elsewhere. This product expansion corresponded with the rise of large supermarket food chains now stocking a range of frozen products using iodised sanitation methods which unwittingly added even more iodine to the dietary intake of Tasmanians.

In 1963 yet another new group of products entered the Tasmanian food chain. This was the uptake of iodine-based sanitisers in the Australian dairy industry to disinfect milk vats, cow teats and other dairy equipment more effectively. These new products were also being used extensively throughout the Tasmanian dairy industry and introduced yet another concentration of residual iodine into widely consumed products. Iodophors were first marketed in Tasmania in 1963 and their use increased rapidly; by 1970 most dairy farmers used them. It was Dr Roger Connolly who first made the connection between the use of iodophors so that when bread iodation began in 1966 iodine deficiency was already being corrected by the iodophor residues in milk. These revelations led George Vidor and I to reconsider our data on the incidence of thyrotoxicosis. This was not routinely recorded until 1966 and it was only when we were retrospectively gathering such information for the pre-iodation years that it was revealed that the incidence had virtually doubled in 1964 and 1965. We had attempted to explain this by increased imports of food, but it was now apparent that it was due to the increasing use of iodophors from 1963 onwards.

Figure 3 shows that there were three occasions when the incidence of thyrotoxicosis rose: in 1964 following the introduction of iodophors in 1963; in 1966–67 after iodine was added to bread in 1966; and in 1971 after milk processors began using iodophors to clean their road tankers. When each of these practices were stopped, the incidence of thyrotoxicosis began to fall steadily. Before this, all reported iodine-induced thyrotoxicosis had followed the deliberate administration of iodine, either as treatment for individual patients or by dietary supplementation to correct iodine deficiency.

NOT SO STRAIGHTFORWARD

By the beginning of 1970 it seemed that the epidemic was over. The incidence of thyrotoxicosis had peaked in 1967 and in the two years following had declined although the level was still higher than pre-iodation. A goitre survey had shown the virtual eradication of juvenile goitre, so although the epidemic was a high price to pay by one generation it ensured future generations would be free from iodine deficiency. Our thinking was soon to be dispelled by two surprises.

In 1972, the distribution of free milk to schoolchildren was discontinued and a decrease in milk consumption followed this withdrawal (430 ml/day in 1973 to 285 ml/day in 1974). 'Big M' flavoured milk came onto the Tasmanian market in October 1978 with a vigorous marketing campaign resulting in an increase per capita of milk consumption to approximately 300 ml/day (Gibson 1995). Iodine excretion showed a rise, due to the additional milk, and is reflected in the incidence of patients presenting

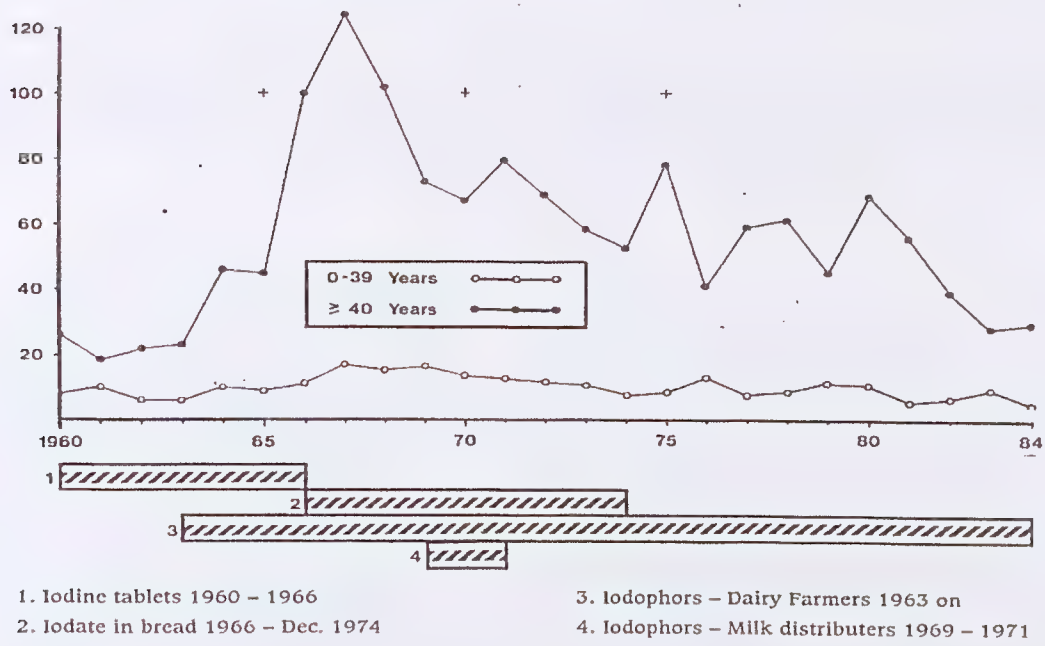


FIG. 3 — Age-specific incidence of thyrotoxicosis cases in the Tasmanian population from 1960 to 1984. (From Gibson 1995)

for treatment of thyrotoxicosis at the Launceston General Hospital. The major rises and falls in such attendances have been consistent with the dietary availability of iodine in the state of Tasmania.

By 1974 bread manufacturers had gradually stopped using the improver containing iodine so from then on bread had ceased to be a source of dietary iodine and without anyone realising it, its place had been taken by milk.

By 1990 the iodophors used as sanitisers in the milk industry were being phased out in favor of chlorine-based sanitisers. At this time the Department of Health stopped monitoring milk as the prevalence of goitre had fallen quite considerably. Dr Heather Gibson, who had been the school medical officer from 1949 to1984, provided a report on iodine-deficient disorders in Tasmania covering the period of her appointment to the Department of Health (Gibson 1995). The situation at the end of 1994 was that after 45 years of iodine supplementation in one form or another (i.e., potassium iodide tablets, iodate added to bread as an improver and iodophor sanitisers introduced to the dairy industry in 1966) we were now only left with iodophors in the dairy industry providing adequate levels of iodine intake in milk for the Tasmanian population.

END OF THE EPIDEMIC

An epidemic can usually be regarded as over when the incidence of the disease returns to the level observed before the epidemic began. This never happened with thyrotoxicosis in Tasmania. Even as late as 1990 the incidence was more than half as much again as that recorded in 1960–63. By 1982, however, the incidence had stabilised at about the level that persisted at least until 1990. The epidemic, therefore, can be said to have lasted from 1964 to 1981. My belief is its long duration is possibly explained by the existence of older people with goitres containing autonomously functioning tissue which, in the 1960s, had not yet grown big enough to cause thyrotoxicosis. Over the ensuing years the autonomous tissue grew and caused them to become thyrotoxic.

The continued raised incidence of thyrotoxicosis after 1982 compared with the years before iodine intake increased is probably an inevitable consequence of the rise in iodine levels. In any population there are a few people in whom thyroid function is no longer under normal control, whether because of Graves' disease or autonomous nodules. An increase in the availability of iodine may lead to increased thyroid hormone production and thyrotoxicosis. Rather than saying that thyrotoxicosis was increased after an increase in iodine intake it could be argued that it was previously depressed by iodine deficiency.

The results of the studies were published in peer-reviewed journals. The first paper, a preliminary communication to the *Lancet*, took some time to complete as it was written in collaboration with Dr Connolly, who by then was serving in Vietnam and drafts had to be exchanged via post. Drs Vidor and Stewart investigated the epidemic assisted by Professor B. Hetzel (Adelaide), Dr C. Eastman (Woden Valley Hospital), Dr D. Adams (Dunedin, NZ) and Dr R. Utiger (Washington, USA) who performed specialist tests to establish the mechanism involved. In 1970 the northern and southern Tasmanian clinics combined their resources which significantly expanded the understanding of thyroid disease and culminated in a number of scientific papers (Vidor *et al.* 1968, Connolly *et al.* 1970, Connolly 1971a, 1971b, 1973, Vidor *et al.* 1973, Adams *et al.* 1975, Stewart *et al.* 1976, Stewart & Vidor 1976). Dr Vidor was an invited speaker at a workshop on iodine-induced thyrotoxicosis held in Boston in 1996 by the International Council for Control of Iodine Deficiency Disorders, and

the proceedings of the workshop were published in the journal *Thyroid* in 1998. In later years these events have continued to be published in books and papers by many research colleagues, and the research continues to this day (Hynes *et al.* 2004, Burgess *et al.* 2007, Richards & Stewart 2007, Seal *et al.* 2007, Richards & colleagues 2020).

WHY TASMANIA AND NOT ELSEWHERE?

There are several theories as to why Tasmania was the site where the first serious epidemic of iodine-induced thyrotoxicosis was described. The combined effect of extra dietary iodine from bread and milk, although not leading to abnormally high intakes, added more iodine to the diet than planned which increased the severity of the epidemic.

In 1966 there were few laboratory tests of thyroid function and most involved radioisotopes. The only isotope laboratories (later to be known as departments of nuclear medicine) were in Hobart and Launceston. This led to a concentration of cases in these two centres making the epidemic more obvious than if the cases had been spread thinly over many practitioners across the state. Iodine-induced thyrotoxicosis must have occurred elsewhere, but the majority of cases were being detected. This is perhaps understandable as much of the work on iodine deficiency in the years after the Second World War was in severely deficient areas such as the Belgian Congo, the Himalayas and the Highlands of New Guinea where medical services were scant and many cases of thyrotoxicosis could go undiagnosed. Furthermore, life expectancy in these countries was such that few people survived beyond the age of 50 years when the risk becomes greater.

CONCLUSION

For the first time the existence of epidemic iodine-induced thyrotoxicosis was irrefutably demonstrated. This caused a global reassessment of the approach to correction of iodine deficiency. It had been made clear that any program of iodine supplementation in an iodine-deficient population carries the risk of causing iodine-induced thyrotoxicosis; and if the population contains many older people, that risk becomes a certainty.

The elimination of iodine deficiency remains as important as ever but is now pursued with greater caution. The dose of iodine is chosen to be as small as is possible while still being adequate to relieve deficiency and medical services are alerted regarding the early detection and treatment of the ensuing thyrotoxicosis.

Tasmania is not assured of environmental iodine stability having discontinued the monitoring of iodine in milk in the mid- to late 1980s. Any rationalisation within the dairy industry (use of iodophor sanitisers) will impact severely on the status of thyroid physiology of Tasmania's population as no other dietary sources would sustain acceptable levels of dietary iodine intake. Potentially the risk of further epidemics of thyrotoxicosis is high especially if unknown sources of iodine supplementation are insidiously introduced to the diet of an ageing Tasmanian population. Despite existing programs of prophylaxis about one billion people worldwide are at risk from iodine deficiency and the prevention of iodine deficiency remains a challenge throughout the developing world.

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(accepted 1 December 2020)

Short Note

TORRES STRAIT TO TASMANIA: NATIONALLY SIGNIFICANT BUTTERFLY COLLECTION HOUSED AT THE QUEEN VICTORIA MUSEUM AND ART GALLERY, LAUNCESTON

by David Maynard

(with three plates)

Maynard, D. 2021 (2:vi): Short Note: Torres Strait to Tasmania: nationally significant butterfly collection housed at the Queen Victoria Museum and Art Gallery, Launceston. *Papers and Proceedings of the Royal Society of Tasmania* 155(1): 69–70. ISSN: 0080-4703.
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In 2019 the Queen Victoria Museum and Art Gallery in Launceston received a donation of one of Australia's largest and most significant private butterfly collections. The Lambkin-Knight collection, containing around 12,000 Australian including Tasmanian specimens, provides an invaluable reference point for butterfly identification, distribution and climate-change related research and has already resulted in over 30 scientific publications.
Key Words: Lambkin-Knight collection, butterflies, QVMAG, conservation, Tasmania.

DONATION OF THE COLLECTION

In December 2019 the Queen Victoria Museum and Art Gallery (QVMAG) received as a donation one of Australia's largest private butterfly collections. The Lambkin-Knight collection has developed over a 45-year period, with the bulk of the collection coming from Tasmania, New South Wales and Queensland. There are around 12,000 specimens representing over 300 species, and the collection includes paratypes, CITES listed species, extremely rare species and extinct species. The collection is spatially and temporally diverse and species-rich. The scientific and research potential of this collection is well established with over 30 publications already based on it. The provenance of each specimen, its rarity and representativeness, the quality of presentation, and its interpretive capacity make this one of Australia's most significant butterfly collections.

Dr Trevor Lambkin is a highly regarded lepidopteran taxonomist based in Brisbane and Ian Knight is a well-known collector of Australian Lepidoptera (both butterflies and moths) now based in northern Tasmania (pl. 1). Trevor and Ian saw the need for their collection to be lodged with an appropriate institution that could care for and maintain it in perpetuity and ensure that it was made available for biodiversity-related research. QVMAG were delighted to accept this wonderful donation and sincerely thanked the donors for their generosity.

This unforeseen acquisition poses an ongoing budgetary issue for the Museum as it is estimated that QVMAG will need 16 purpose-built entomology cabinets to properly house the collection at a purchase cost of approximately $58,000. However, thanks to the generosity of the Royal Society of Tasmania (Northern Branch), QVMAG Friends (https://www.qvmag.tas.gov.au/Support-Us/Friends), Plomley Foundation and Australian Entomological Supplies, QVMAG has been able to purchase the first six cabinets already. Fundraising efforts continue.

CONSERVATION VALUE

The Lambkin-Knight collection is an important addition to the QVMAG Natural Sciences entomology collection for two primary reasons. Firstly, it provides a high-quality reference collection of Tasmanian, mainland Australian and

Plate 1 — Donor and lepidopteran collector Ian Knight kindly helping to curate the collection after it arrived at QVMAG from Brisbane. (Photo supplied by author)

island butterfly species (pl. 2). Of immediate relevance to QVMAG are the Tasmanian and southeastern Australia butterflies as these provide us with a snapshot of species distributions, and the means to identify specimens (pl. 3). Secondly, it will support climate change-related research; as species ranges begin to shift poleward, altitudinally or into different climate zones.

The spatial and temporal distribution of the Lambkin-Knight butterfly collection makes it an important national research resource. Over the coming years QVMAG staff will be working hard to make the collection data available through the Atlas of Living Australia (https://www.ala.org.au/) so that all researchers have open access to this information.

(accepted 6 Nov 2020)

Plate 2 — Tropical specimens in the Lambkin-Knight butterfly collection. (Photo supplied by author)

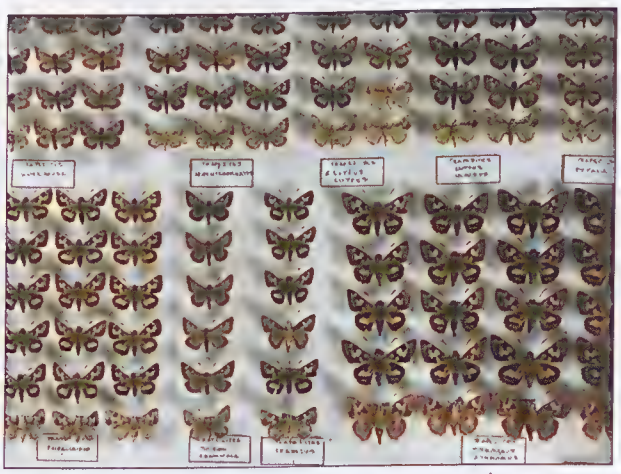

Plate 3 —Tasmanian specimens in the Lambkin-Knight butterfly collection. (Photo supplied by author)

AQUARIUM INDUSTRY OFFERS HOPE FOR TASMANIA'S CRITICALLY ENDANGERED HANDFISH

by Rachelle Hawkins

(with two text-figures, one table and ten plates)

Hawkins, R. 2021 (2:vi): Aquarium industry offers hope for Tasmania's critically endangered handfish. *Papers and Proceedings of the Royal Society of Tasmania* 155(1): 71–77. ISSN: 0080–4703. Seahorse World, 200 Flinders Street, Beauty Point, Tasmania 7270, Australia. Email: rachelle@seahorse-australia.com.au

Southeast Australia, and most notably Tasmania, is the last home to the Handfishes, a unique group of marine fish that use their fins for walking. A range of threats occur across all species, with four listed as endangered, two as critically endangered, and the Red Handfish now on the brink of extinction. This paper summarises the contribution being made to the national recovery of the Spotted Handfish and Red Handfish by a captive breeding project underway at Beauty Point in northern Tasmania. Information is provided on husbandry techniques, survival and growth rates in captivity and a trial underway to identify their reproductive strategies. This program highlights the contribution the aquarium industry can make to improving the survival of two of the world's most unique species of marine fishes and the collaboratives efforts of those involved.

Key Words: Spotted Handfish, *Brachionichthys hirsutus*, Red Handfish, *Thymichthys politus*, Tasmania, critically endangered species, IUCN Red List.

INTRODUCTION

Handfishes (Family Brachionicthydae) are the most threatened bony fish family in the world, with seven of 14 species now listed as either Critically Endangered or Endangered on the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species (Stuart-Smith *et al.* 2020). In 1996 the Spotted Handfish *Brachionichthys hirsutus* was the first marine fish to be placed on the IUCN Red List of endangered species, and their range is limited to the temperate waters of southeastern Australia, predominantly Tasmania (Stuart-Smith *et al.* 2020). However, this was not always the case as fossil evidence shows they once inhabited many estuary systems around the world (Carnevale & Pietsch 2010), but their tendency to inhabit shallow waters near urban areas and their low mobility has made them vulnerable to a range of disturbances, and over the past 40 years there has been a rapid decline in Spotted Handfish numbers. Furthermore, in the 1960s and 1970s handfish were routinely collected for practical demonstrations at Hobart's university (Lynch 2017) as they made attractive teaching tools, and their numbers were presumably more abundant at this time. This decline triggered the CSIRO (Commonwealth Scientific and Industrial Research Organisation) in Hobart to commence regular field research, population monitoring and habitat protection measures.

In 1997 scientists at CSIRO conducted their first trial of captive-rearing young, with the view to releasing them back to the wild to boost natural populations (Bruce *et al.* 1997). Field research has continued to be a strong focus for CSIRO, especially population monitoring, but also monitoring habitat quality and extent and trialling protective measures (Lynch 2019). Three main factors have been identified as significantly contributing to the Spotted Handfish's demise: the limitations of their biology, the invasive Pacific Seastar *Asterias amurensis* and urban development degrading their habitat.

In 2019, the critically endangered Red Handfish *Thymichthys politus* was estimated to have fewer than 100 individuals left in the wild and restricted to just two small localities in southeastern Tasmania (Stuart-Smith *et al.* 2020). Its dramatic decline is attributed to its fragmented populations and local increases in the density of native Purple Sea Urchins *Heliocidaris erythrogramma* which overgraze the seaweed habitat it requires for shelter and spawning (Stuart-Smith *et al.* 2020).

Scientists are also addressing the demise of the Spotted and the Red Handfish by breeding and raising them in captivity to learn more about their biology and to provide surplus animals for restocking. Initial breeding and re-stocking attempts were conducted with Spotted Handfish at CSIRO as early as 1997, and due to the continued critical status of the species, this work is being expanded with support from practitioners at Seahorse World in Tasmania, the Zoo and Aquarium Association, the National Environmental Science Program (NESP) and the SEA LIFE Melbourne Aquarium (Lynch *et al.* 2017).

This paper provides an overview of two handfish species currently being managed in captivity by Seahorse World in northern Tasmania as part of national recovery efforts to improve their conservation status (Commonwealth of Australia 2015). It presents new information on their behaviour, housing and husbandry conditions and demonstrates how the aquarium industry can play an important role in their recovery program.

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HANDFISH BIOLOGY AND THREATS

Handfish belong to the Family Brachionichthyidae, which comprises 14 extant species all globally restricted to southeastern Australia, with 11 occurring in the seas around Tasmania (Threatened Species Section 2020). Brachionichthyids produce relatively few eggs (approximately 50 to 150 for the three species for which this is known). In addition to these species' low fecundity, their eggs have low dispersal ability due to the lack of a larval stage – meaning the fish hatch as demersal, fully formed juvenile handfish (Stuart-Smith *et al.* 2020). Their unique biology includes their preference to walk on their pectoral fins rather than swim, and this feature compounds the low level of dispersion of the species.

Pacific Seastar

The Pacific Seastar *Asterias amurensis* is a pest from the northern hemisphere introduced into Tasmania in ballast water in the 1980s (Rainer 1995). While it now occurs all around Tasmania, it is most common in the Derwent Estuary. During reproduction (which can occur sexually or asexually), a female Pacific Seastar releases up to 20 million planktonic larvae into the water, where they remain pelagic for 120 days before metamorphosing into juvenile starfish and becoming sexually mature within 12 months (NSW Department of Primary Industries 2017). The Pacific Seastar is well known as an opportunistic predator, consuming a diverse range of epifauna, including stalked ascidians, the preferred natural spawning habitat of Spotted Handfish (Stuart-Smith *et al.* 2020). The control of Pacific Seastar populations is very difficult and experiences in Port Phillip Bay suggest that once a population is established there is little chance of successfully eradicating it (Parry & Cohen 2001).

Habitat degradation

Some of the preferred habitat for the Spotted Handfish is on the seafloor in shallow waters which are ideal sites for urban developments, especially marinas. Marinas with traditional mooring systems are catastrophic for the Spotted Handfish, as every time the wind swings the boat around its moorings, the heavy chain mooring drags along the sea-floor, destroying any egg-mass laid in its path and at the very least, disturbing the handfish, if not causing it physical damage or death. CSIRO are now developing a type of mooring to mitigate these problems. These environmentally friendly moorings do not have a heavy chain but instead they float above an anchor-based weight thereby minimising any interaction with the sea floor (Lynch *et al.* 2020).

Artificial Spawning Habitats (ASH) have been developed and planted out in known handfish habitat where the natural stalked ascidians have been depleted and repeat monitoring has shown these ASHs have been utilised successfully for spawning by the handfish (Lynch *et al.* 2020).

PROGRAM AIM

The goals of the initial project at Seahorse World were:

- to hold and maintain handfish in captivity
- to breed handfish in captivity
- to educate the public about handfish, their plight and conservation efforts
- to raise the next generation of handfish
- to re-stock the Derwent River with healthy juvenile handfish

To achieve these aims it was necessary to:

- research previous Spotted Handfish projects carried out by CSIRO in 1997.
- assign a staff member to be singularly responsible for handfish daily care.
- invest in a high-quality, reliable chiller and lighting equipment to provide their fundamental needs for dissolved oxygen, correct salinity and stable water quality but also mimic the changing photoperiod conditions of the Derwent Estuary to promote breeding.
- have access to a continuous source of live amphipods for food.
- be equipped to provide adequate live food for offspring, should we achieve a successful breeding event.
- have multiple safeguard systems in place to ensure adults and eggs were not all at-risk should systems fail.

HUSBANDRY

In late 2017, ten wild-caught, adult Spotted Handfish were transported to Seahorse World, which is located on the Tamar River in northern Tasmania. They were housed in an off-display research area until they acclimatised and were deemed comfortable enough to be on public display. In December 2018, 16 Red Handfish hatchlings were transported from CSIRO to the same facility. Husbandry methods employed and refined over 22 years of seahorse farming proved invaluable for caring for the handfish, and both species were found to be readily amenable to aquarium conditions.

Diet

Live adult amphipods were fed to both species of adult handfish at this time. The dominant species of amphipod in the lower Tamar area is *Bellorchestia pravidactyla* (pl. 1), a common sandhopper species that burrows in sand beaches (Hughes & Ahyong 2017).

On day four of housing the wild Spotted Handfish adults, it was exciting to find they had laid eggs on the artificial ceramic spawning pole (ASH) that had been supplied by CSIRO (pl. 2).

By day 21, eyes were visible inside the eggs. After an incubation period of 54 days the eggs hatched over a two-hour period, with 81 hatchlings resulting. Like Pot-bellied Seahorses *Hippocampus abdominalis*, the Spotted and Red handfish hatchlings were capable of feeding on Instar II *Artemia salina* from day one, and this was their

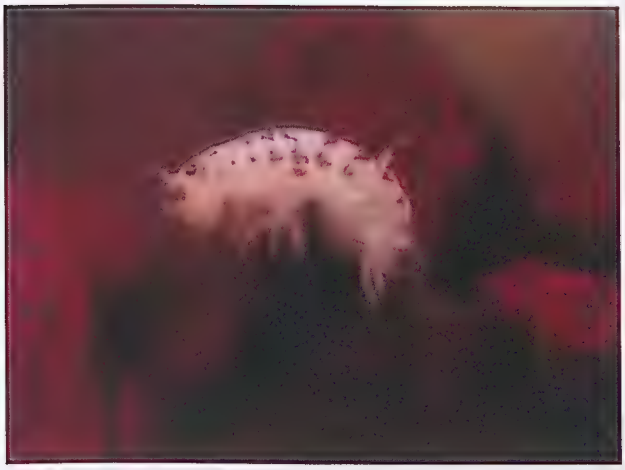

PLATE 1 — Amphipod *Bellorchestia pravidactyla* fed to handfishes. Body length approx. 9 mm. (Photograph: Tegan Blackwell)

PLATE 2 — Adult Spotted Handfish *Brachionichthys hirsutus* with eggs. (Photograph: Christopher Carey)

PLATE 3 — Juvenile Spotted Handfish feeding on live *Artemia salina*. Hatchling body length approx. 12 mm. (Photograph: Christopher Carey)

PLATE 4 — Juvenile Red Handfish. Note prominent illicium. (Photograph: Jesse Chippindall)

sole diet for four weeks until they were large enough to ingest larger prey. *Artemia salina* were an excellent prey candidate, as they exhibited the 'live prey' movement, could be enriched to suit dietary needs, and could be grown to larger sizes to suit the changing prey size needs of the growing handfish. The limitations of *Artemia salina* as a prey item was that the handfish are typically demersal, and so would only pursue the *Artemia* that swam close to the substrate. This resulted in the vast majority of *Artemia* remaining unconsumed at each feeding session and subsequently flushed out of the outlet resulting in a significant waste of the food source. While it is possible that the uneaten *Artemia* could be re-offered, this poses problems with pathogen transfer and loss of enrichment, and so was never employed, opting instead for fresh, high-quality *Artemia* for every feed session. This was where weaning on to live amphipods was important. As soon as a reliable quantity of amphipods could be sourced that were a suitable size for the juvenile handfish gape (pl. 3), they were transferred onto this diet. The handfish readily switched over to this diet and were regularly observed to use their illicium to attract the prey (pl. 4). The full role of the illicium is still being studied.

Temperature and light regime

It was important to be conservative with temperature throughout the project, as a fatal problem encountered in previous experiments by CSIRO scientists occurred when temperature exceeded 18°C, to an unknown extreme. Therefore, while attempting to mimic the temperature trends of the Derwent Estuary as much as possible, temperature settings erred on the culture water being cooler, rather than overly warm. While this may have potentially slowed handfish rate of growth, ensuring survival was considered a higher priority in the early stages of the project. A focus of future work would be to identify the optimum temperature regime promoting growth while ensuring survival.

Considerable efforts were undertaken to supply aquaria with a source of light that could mimic the photoperiod of the Derwent Estuary and be programmed for wavelength and intensity throughout this period. The lights purchased were employed for the first 12 months of the project; however, their unreliability caused constant power interruptions, and they were eventually abandoned due to safety concerns.

While on display, handfish were housed in tanks which had a more natural appearance including a substrate they could forage in for food (pls 5, 6), but when off display they were housed in bare-bottom tanks which allowed easier removal of faecal matter, uneaten/dead amphipods, and improved disease control. The handfish did not appear to be adversely affected by being housed in a non-natural environment and in these tanks it was also found that less food was wasted, as the live amphipods could not retreat under the substate to escape being eaten. After two years of growing the young, and prior to their re-stocking in the Derwent River, the Red Handfish were transferred to CSIRO laboratories to a tank which more closely resembled the natural environment, to aid their transition to the wild.

Daily care

Daily care involved providing live food, tank cleaning and water quality management. This involved frequent trips to the beach to collect live Amphipods (*Bellorchestia pravidactyla*). To feed the juveniles, live *Artemia salina* were hatched out and grown in this facility and delivered to the handfish twice daily.

Tanks were siphoned to remove faeces and uneaten food. Water quality parameters were measured regularly and maintained within the optimum range by water changes. Natural seawater was pumped up from the Tamar River and filtered to 0.2 µm through a membrane filter and chilled or heated to the appropriate temperature. UV sterilisation was used on some of the handfish systems. The temperature of the handfish was controlled by air-conditioning and in-line chillers.

Handfish health

Health was also monitored with any signs of disease treated promptly and all mortalities investigated by the University of Tasmania or Mt Pleasant Laboratories. Post-mortem results often showed the presence of scuticociliates (free-living marine unicellular organisms) colonising the fish, but it was unknown as to what extent this occurred before fish death. Some of the wild-caught handfish were also infected by parasites; however, these infections were considered unlikely to have led to fish death.

GROWTH RATES IN CAPTIVITY

Figure 1 and figure 2 show growth rates of the two handfish species maintained in captivity at Seahorse World. The fastest growth rate in Spotted Handfish occurred during the first year, followed by a year when the average length did not change before resuming growth (fig. 1).

A more uniform growth rate was observed for the Red Handfish under culture over a two-year period.

Much of the project has also been devoted to observing the handfish and documenting their behaviour including using their fins and illicium (pls 7, 8). Handfish research is very much in its infancy, and therefore any information that could be gleaned on their behaviour, interactions and responses was recorded. This included watching them feed, swim, their startle response, interactions with each other, defecation and respiration.

PLATE 5 — Spotted Handfish. Note the illicium below the eye. (Photograph: Tegan Blackwell)

PLATE 6 — Red Handfish investigating foraging substrate. (Photograph: Rachelle Hawkins)

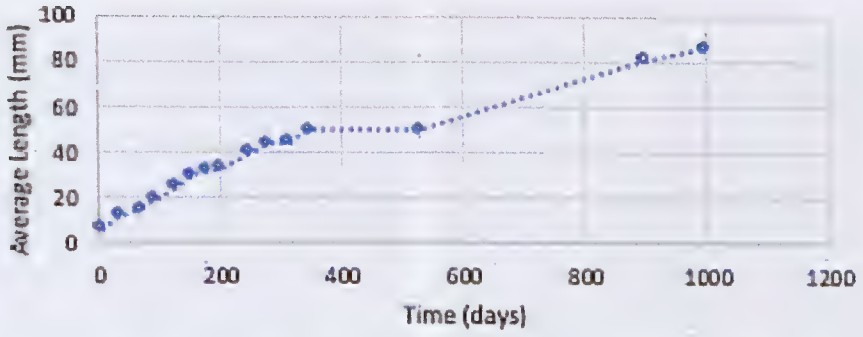

FIG 1 — Growth rate of Spotted Handfish *Brachionichthys hirsutus* in captivity (n = 25).

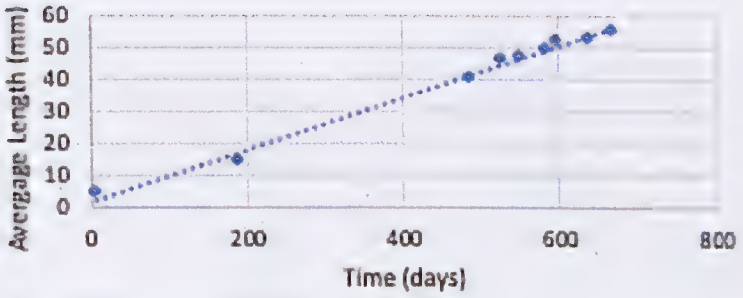

FIG. 2 — Growth rate of Red Handfish *Thymichthys politus* in captivity (n = 16).

SPAWNS

As mentioned, a highlight of the project occurred in November 2017 when the wild-caught adult Spotted Handfish successfully spawned in captivity using the ASH pole provided. This resulted in the batch of young now raised to maturity. A second spawn occurred in a Spotted Handfish tank containing two handfish and, although these eggs were not fertilised, the female tended them in a similar manner to the female tending fertilised eggs. When these two adult handfish died later in the project, it was revealed that both fishes were female, hence why no fertilisation occurred. Learning how to differentiate between the sexes will be essential for the ongoing success of this project.

The Red Handfish that produced the hatchlings is housed in an off-display production area. She has spawned

PLATE 7 — Red Handfish, adult body length approx. 67 mm. (Photograph: Tegan Blackwell)

PLATE 8 — Spotted Handfish with fully erect fins. Adult body length approx. 95 mm. (Photograph: Tegan Blackwell)

PLATE 9 — Gravid female Red Handfish. (Photograph: Tegan Blackwell)

PLATE 10 — Female Red Handfish tending her eggs. (Photograph: Jesse Chippindall)

twice since (pls 9, 10), but no fertilisation has occurred, despite the presence of two additional adult handfish (of unknown sex status).

An exciting development has recently occurred at SEA LIFE Melbourne, which is housing wild adult Spotted Handfish. Ultrasound technology has been utilised to inspect the gonads of mature handfish to determine their sex and this technology could be invaluable in assisting future breeding programs.

TRIAL IN PROGRESS

Studies investigating the role of stocking densities on breeding success are currently underway at Seahorse World. It has been observed that the Red Handfish adult held at the facility produced eggs three times in three years, while being alone in a tank. Spotted Handfish are almost always observed alone in the wild, except during the breeding season when they come together (Tim Lynch pers. comm. 2020). To test the hypothesis that handfish more readily develop mature eggs while being separate from other adults, and before coming together for breeding, we are trialling seven systems (table 1).

Each system has its own water recirculation system. Tanks within a system share water and have largely similar water quality to each other. Each tank contains at least one artificial spawning pole. After 30 days of isolation, the Spotted Handfish in Systems 3 and 4 will be combined and their behaviour observed. The major limitations of this trial are that the sexes of adult handfish remains difficult to determine and only a relatively small number of individuals are available to undertake multiple replicates.

More studies underway include observation and monitoring of handfish respiration, handfish colouration in various coloured substrate, and the species' startle response.

CONCLUSION

All the stated goals of this program were achieved to varying degrees of success:

- Seahorse World was able to successfully provide the conditions needed for keeping Spotted and Red Handfish in captivity.
- One successful breeding event occurred during the project, and a further three unfertilised spawns occurred, confirming that females can produce eggs in captivity.
- During 2018–19, over 90,000 visitors to Seahorse World were able to view Spotted and Red handfish on display, helping raise awareness about handfish vulnerability and efforts underway to aid their recovery. For the majority of 2020, visitation was interrupted by the COVID-19 pandemic.

Though captive breeding was not without its losses, 25 Spotted Handfish have now been successfully raised to maturity, and 11 Red Handfish are approaching mature size. In October 2020, eight Red Handfish juveniles born and raised in captivity were individually marked with a fluorescent marker and released into the Derwent River, in an undisclosed location determined by the Handfish Recovery Team as an optimal site for re-stocking. Being able to provide animals for this action confirms the contribution captive breeding can make towards boosting population numbers of handfish in the wild and the significant role the aquarium industry can play in this recovery program.

FUTURE FOCUS

The work underway at Seahorse World in northern Tasmania has identified several future research areas to aid handfish recovery. These include:

- being able to sex handfish to aid captive pairings and breeding success
- varying nutritional input by varying diet
- determining optimal temperature for growth and survival
- understanding the role of the illicium
- identifying optimal stocking density and sex ratio for breeding
- varying photo period to determine the effect on breeding.

Ongoing fieldwork to monitor wild handfish populations and to re-sight released individuals is also needed to help measure program success.

TABLE 1 — Aquaculture systems varying the stocking densities of Spotted and Red handfish

System	Tank A	Tank B	Tank C	Tank D
1	1 Spotted	3 Spotted	2 Spotted	2 Spotted
2	10 Spotted			
3	1 Spotted			
4	1 Spotted			
5 Ambassador	5 Spotted	2 Spotted		
6 Ambassador	3 Red			
7	1 Red (wild)	2 Red (wild)		

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(accepted 5 March 2021)

ROBOTIC EXPLORATION BENEATH THE ICE: THE CHALLENGES, RISKS AND REWARDS OF DEPLOYING AN AUTONOMOUS UNDERWATER VEHICLE IN ANTARCTICA

by Peter King

(with four text-figures and one table)

King, P. 2021 (2:vi): Robotic exploration beneath the ice: the challenges, risks and rewards of deploying an autonomous underwater vehicle in Antarctica. *Papers and Proceedings of the Royal Society of Tasmania* 155(1): 79-84. ISSN: 0080-4703. Autonomous Maritime Systems Laboratory, Australian Maritime College, University of Tasmania, Maritime Way, Newnham, Tasmania 7248, Australia. Email: p.d.king@utas.edu.au

Measurements beneath Antarctic ice shelves are critical to our understanding of how the glaciers will change and melt. To access these regions, we rely on autonomous underwater vehicles (AUV), which are free-swimming robots. The Australian Maritime College in Launceston, Tasmania, is leading efforts to deploy these vehicles in some of the harshest environments on Earth. This paper provides an overview of the history and recent Australian efforts in deploying AUVs in under-ice environments and discusses recent advances in mission planning and the ongoing challenges to take measurements from beneath ice shelves.

Key Words: Antarctica, autonomous underwater vehicles, AUV, Australian Maritime College, Tasmania.

INTRODUCTION

A major consequence of climate change is the potential for sea-level rise due to the melting of Antarctic glaciers (IPCC 2019). The main contributor to this ice-mass loss is melting at the base of ice shelves, i.e., the floating extensions of glaciers, driven by ocean processes (Liu *et al.* 2015). Understanding the ocean properties beneath the floating ice shelf is key to understanding the mechanisms involved and the rate at which ice loss will occur.

Ice shelves may be tens to hundreds of metres thick and extend hundreds of kilometres from the grounding line, the point at which the floating ice shelf meets the continent. In addition, ocean depths around the ice shelves can range from hundreds to thousands of metres. What this means is that the areas beneath floating ice shelves are some of the most inaccessible regions on Earth (Dowdeswell *et al.* 2008). Figure 1 illustrates the general geometry and parts of an ice shelf.

One primary technology that allows collection of critical data in these formidable zones is an autonomous underwater vehicle (AUV). An AUV is a free-swimming robot, which does not rely on ongoing human control or any physical tether. They can carry a suite of sensors to measure critical areas of interest though self-guidance and unaided navigation, executing instructions provided by the operators.

Deployment of these AUVs under ice has immense benefits for our understanding of the interaction between the ocean and cryosphere. Deployment, however, comes with equally immense engineering challenges due to: the remoteness of the region; the lack of prior knowledge about the environment; and an invariant – that failure of any of the many sub-systems can lead to a total loss, due to the physical barrier presented by the vast ice mass. Put simply, there are no rescue plans for an AUV trapped under ice.

History

The use of AUVs beneath ice began in 1972 with the deployment of the Unmanned Arctic Submersible (UARS) beneath the Fletcher ice-island by the University of Washington's Applied Physics Laboratory (Francois & Nodland 1972). Further advancements saw the development and testing of the Autonomous Conductivity Temperature Vehicle in 1989 (Light & Morrison 1989) and the *Odyssey II* in 1993 and 1994 (Bellingham *et al.* 1993, 1994).

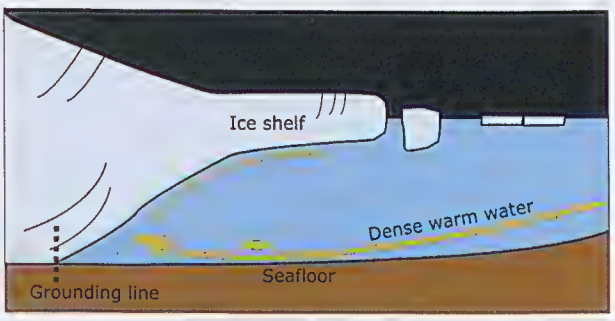

FIG. 1 — Geometry and parts of an ice shelf (not to scale). The diagram shows how the glacier flows from the continental ice sheet toward the ocean, forming a floating ice shelf. The point at which the glacier is still in contact with the seafloor is the grounding line. Icebergs are the large pieces of ice that break off the ice shelf. Sea ice is formed as seawater freezes, often in areas near ice shelves. Dense warm and high-saline water is heavy, and thus flows along the seafloor into the ice shelf cavity.

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Great advancement in AUVs occurred in the late 1990s when International Submarine Engineering deployed the *Theseus* AUV for a record-breaking round-trip journey of over 300 kms beneath Arctic sea ice (Ferguson 1998). This vehicle incorporated many of the technologies still used today and made apparent that the technology could be used in these harsh environments at a meaningful magnitude of scale.

These pioneering deployments were critical, but still focused on sea ice; the bigger challenge of venturing beneath a floating ice shelf would remain unmet until 2005, when the UK's National Oceanographic Centre (NOC) would deploy their *Autosub 2* beneath the Fimbul Ice Shelf, in the Weddell Sea. The *Autosub 2* ventured 25 km into the cavity, surveying the seafloor on the incursion leg, and, for the first time, surveyed the basal surface of the ice on the excursion (Dowdeswell *et al.* 2008).

The *Autosub 2* missions also provided an unfortunate first – the loss of an AUV beneath the ice. On its last mission beneath the Fimbul Ice Shelf, the vehicle failed to return. This event manifested the worst-case estimates of loss probability for AUVs beneath ice and would shape how all future missions would be managed. The event also sparked important research into the study of risk and loss.

Tasmania's *nupiri muka* ('eye of the sea')

In 2014, the Australian Research Council Special Research Initiative, the Antarctic Gateway Partnership (AGP), began. This collaboration between the University of Tasmania (UTAS), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the Australian Antarctic Division (AAD), had the aim of building further polar research capability in Tasmania (AGP 2020). The program was divided into four research themes: Cryosphere-ocean interaction; Open water and under-ice foodwebs; Solid earth-cryosphere interaction; and Marine technology and polar environments.

The marine technology theme's primary activity was the specification, acquisition and deployment of an AUV capable of operation in ice-covered waters and beneath ice shelves. This vehicle would serve to provide critical data to the other three research themes. In May of 2017, following a period of vendor selection, specification, factory tests and sea trials, the new AUV, built by International Submarine Engineering, arrived at the newly built Autonomous Maritime Systems Laboratory, located on the campus of the Australian Maritime College, Launceston. The vehicle was granted the palawa kani name, *nupiri muka*, meaning 'eye of the sea' by the Tasmanian Aboriginal Centre. Figure 2 illustrates the *nupiri muka* AUV in its original delivered state, showing the key internal components. Table 1 gives the key specifications as delivered and with subsequent upgrades.

CHALLENGES

There are key challenges to be met when deploying an autonomous robot in a remote and dynamic environment such as under ice.

Navigation

Electromagnetic signals do not propagate well through seawater, thus, an AUV has no access to a ubiquitous positioning source such as GPS (Al-Shamma'a *et al.* 2004). As these vehicles traverse tens to hundreds of kilometres beneath ice, attempting to return to a pre-determined recovery site and knowing its location becomes the primary challenge for an autonomous vehicle deployment. In lieu of GPS, some underwater vehicles use acoustic signals to provide positioning, but this requires deployment of beacons, which is limited by propagation ranges of tens of kilometres. In ice-covered regions, this becomes prohibitively difficult due to the physical barrier of the ice, hence beacons are often unfeasible for deployment. Long-range, under-ice deployment, as described here, is predicated on the ability of the AUV to maintain its own estimate of position and trajectory, unaided by external supports.

Modern AUVs use extremely high-quality, fibre-optic orientation and heading sensors capable of providing sufficiently accurate estimates of a true-north relative heading. When the AUV is operating in proximity to the seafloor, it can avail itself of onboard Doppler acoustic sensors to measure its velocity relative to the seafloor. The combination of heading and velocity allows for dead reckoning of the AUV's position, relative to a known start position from where it was launched.

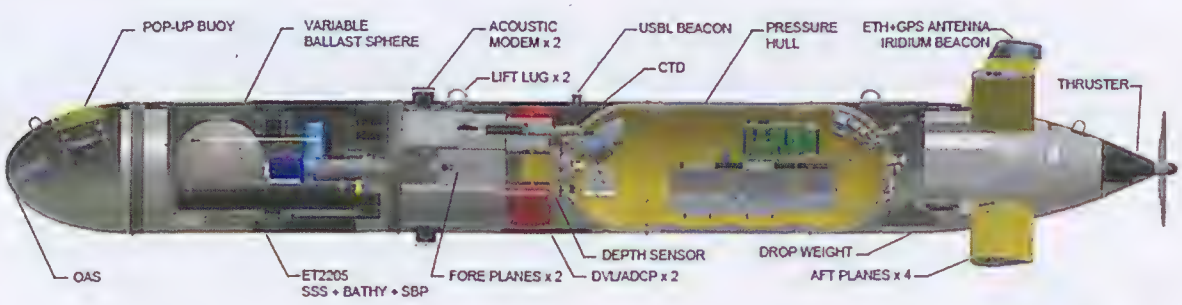

FIG. 2 — The *nupiri muka* AUV with labelled sub-components. The section labelled 'pressure hull' maintains a dry space for computers and batteries, whilst the remainder of the AUV is free flooding.

TABLE 1 — *nupiri muka* specifications

Attributes	As delivered	Upgraded
Length	6.5 m	7.6 m
Weight	1600 kg	1800 kg
Depth rating	5000 m	
Endurance	120 km	240 km
Navigation	Fibre-optic Gyroscope w/ Doppler velocity	
Variable ballast	±50 kg	
Obstacle Avoidance	Forward-looking sonar	
Sonar	- Sidescan Seafloor imagery w/Bathymetry - Sub-bottom profiler	Multibeam Bathymetry
Oceanography	- Conductivity, temperature - Water velocity	- Turbidity, Dissolved Oxygen - Trace-metal clean water sampler

Unknown and dynamic environment

An AUV must traverse an unknown area safely, avoiding the topology of the seafloor as well as the ice above. As previously stated, there is likely no prior knowledge of the locations or shape of either. Travelling towards its intended waypoint, the AUV must detect and guide itself safely through the cavity. This is accomplished by using a vertical swath of sonar beams that project forward from the AUV, which can detect the seafloor, ice and water column ahead of the vehicle. Pre-tuned algorithms determine the slope of the seafloor and range to any physical obstacles in the AUV's path. The AUV will, at first, attempt to adjust its vertical trajectory to pass unhindered, but if it is unable, the fault logic will cause the AUV to abort its trajectory and return towards the safe starting position.

In addition to the unknown topology of the seafloor and ice, there is a dynamic element where the ice may not be static. In areas with sea ice coverage and icebergs, there can be substantial movement over the temporal scale of a mission. Again, the AUV must be able to sense the world in front of it and react accordingly.

Loss under ice

The risks of operating an autonomous vehicle are greatest in ice-covered regions due to the physical barrier of ice, which prevents rescue of the AUV should it falter, and limits deployment of communication and position-aided infrastructure. In addition, the dynamic nature of floating ice can cause openings to close and move throughout the duration of a mission. This can, in turn, lead to safe launch and recovery sites not remaining a static location, thus impeding the AUV's return.

For AUV operations, in which a complex, robotic system must operate unaided and respond to the environment with no human interaction, the ice barrier can elevate even the most benign fault or failure to a catastrophic loss. Thus, planning and review of systems and instructions stages are critical. The mission and instructions provided to the AUV must be as such to provide the maximum chance of successful completion and recovery. The approach taken to address this challenge is described in the following section.

ANTARCTIC MISSIONS

The *nupiri muka* AUV has been deployed in Antarctica over two seasons. The 2018–19 season marked its maiden voyage, when it travelled to the Sørsdal Glacier in East Antarctica and in 2019–20, it went to the Thwaites Glacier in West Antarctica.

Preliminary work

Prior to its maiden voyage to Antarctica, the *nupiri muka* team convened a panel of experts in the field of polar AUV deployment to glean a set of best practices. This 'expert panel' met over three days and presented a series of findings (King *et al.* 2018), or 'best practices' for deployment of an AUV beneath ice. A methodology was then prescribed for creating risk-averse mission plans, described further by King *et al.* (2020).

A primary approach, when feasible, is to conduct a preliminary, mock mission prior to the high-risk mission. For under ice, this is a shortened version of the larger mission, in which the AUV would conduct a preliminary dive and approach to the ice along the same trajectory as the final mission but stopping and returning just prior to breaching the ice edge. The concept behind this approach is that most systematic and human errors can be caught early and corrected prior to commitment. The behaviour and response of the AUV can be analysed in situ.

Secondarily, the mission itself is constructed. Each mission is built on a strict set of sub-tasks, always undertaken in the same manner. A critical invariant is that the AUV never progresses from one sub-task to another, unless directed by the human observer or by way of a fault response. At the end of a mission, either through success or failure, the AUV will always strive to return to its initial safe location.

Initial dive – the AUV performs a vertical spiral to get to its working altitude or depth directly below the ship or support craft. This allows for minimisation of navigation error during the dive and maximises the effectiveness of acoustic communication devices.

Safe loiter – the AUV lingers beneath the surface vessel until commanded over acoustics to begin its incursion leg. If no such command is received, the AUV will eventually time-out and await further instruction or recovery.

Mission incursion – the AUV begins its mission incursion towards the ice. At any time if a fault or system value is out of tolerance, it will return to the safe-loiter location.

Mission return – if the endpoint is reached, the AUV returns to the safe-loiter location.

Sørsdal Glacier

In November 2018, the *nupiri muka* AUV was transported to Davis Station in East Antarctica aboard the RSV *Aurora Australis* for a capability demonstration of the AUV and team. The AUV was partially dismantled to fit within a standard 20-foot shipping container and was made ready on its arrival at the station. Local sea ice conditions at the station delayed AUV operations until late January 2019. Once clear, the AUV was deployed from the station via the boat ramp and transitted nearly 20 km westward towards the Sørsdal Glacier Ice Shelf where it conducted several preliminary dives to gather information regarding the seafloor morphology and oceanographic conditions. This was the first such survey ever of the area; no prior measurements of ocean depth had been conducted.

In early February 2019, following several return trips to the ice shelf, the AUV was deployed beneath the ice shelf, following the seafloor on a 200-m incursion and then on a 500-m mission. Several days later, a subsequent mission sent the AUV on a 700-m incursion, transecting a large crack that had begun to open on the ice shelf. A total of three under-ice missions were conducted, collecting seafloor imagery and bathymetry, ice depth and morphology, and ocean temperature and salinity (fig. 3). As presented by Gwyther *et al.* (2020), these were the first ever such measurements in the area and included the discovery of a deep ocean trough extending into the glacial cavity, as well as a dense mass of cold water, which is likely preventing the incursion of warmer water, thus maintaining low-melt rates of the ice shelf.

Thwaites Glacier

At the end of 2019, *nupiri muka* departed New Zealand aboard the *Korean IBRV Araon* for the Thwaites Glacier region in West Antarctica. This mission was part of an international effort to determine the factors contributing to the rapid melting of the Thwaites Glacier, often referred to as the 'doomsday glacier' (Rowlatt 2020). Following a two-week journey to the region and a series of ship-based science activities, AUV deployments began in early February 2020. Locations of deployments were limited due to a massive band of sea ice extending 20–80 km out from the edge of the ice shelf.

The AUV was launched from the stern of the ship utilising a UTAS-built extendable ramp. Over five days, *nupiri muka* conducted six under-ice missions, beginning with 1-km incursions and working towards a maximum incursion of 30 km. In total the AUV conducted nearly 80 km of under-ice survey, mapping areas suspected to be pathways for warm water traversing towards the ice cavity (fig. 4). Due to the massive sea ice extent that season, the AUV was unable to reach the ice shelf itself.

Preliminary analysis of the data has been presented by Kim *et al.* (2020) utilising the AUV collected temperature data in conjunction with ship-based observations. A notable first on this deployment was the inclusion of a trace-metal clean-water sampler, which was able to collect over 40 samples along the entire incursion beneath the ice (analysis of this data is forthcoming).

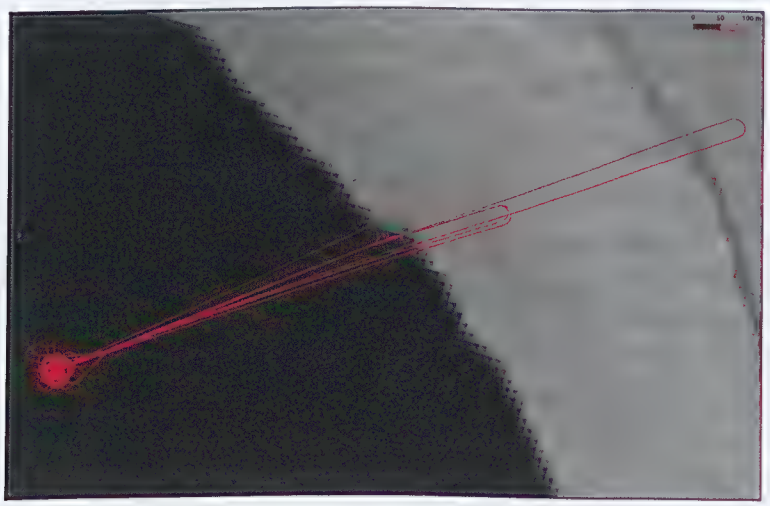

FIG. 3 — AUV track from Sørsdal Glacier ice shelf.

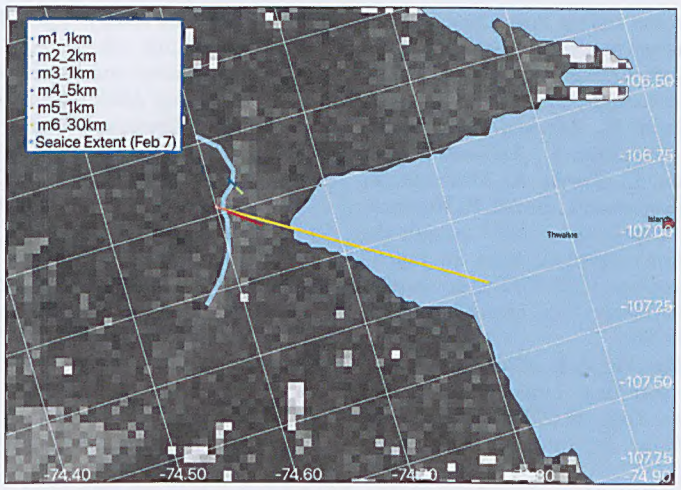

FIG. 4 — AUV missions at the Thwaites Glacier.

SUMMARY

Under-ice deployment of AUVs is a high-risk, high-reward activity. Deploying these free-swimming robots is a primary means of collecting some of the most critical data used to support our understanding of how ice shelves are changing and at what rate. Bore holes and lowered instruments can provide point sampling, but it can be argued that an AUV is the only means by which data across a geographic area from the region beneath a floating ice shelf can be collected.

The next five to ten years will see the team at the Australian Maritime College expand its international collaborations and return to Antarctica for longer and more ambitious missions. Further developments in risk mitigation, autonomy and battery technology will be key to these future deployments. In addition, more diverse vehicles and collaboration between multiple vehicles will frame the next generation of under-ice exploration.

Operating in these areas is fraught with challenges and risk, which are overcome through a combination of technology, engineering and planning. The future will see more AUVs visiting these areas, conducting more ambitious incursions each time. The risk of loss will always be present, but mitigation and the promise of reward will keep this a worthy endeavour.

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